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A Strategy and Results Framework for the CGIAR

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Document presented for Agenda Item 3:
Presentation of the SRF, including examples of Impact Pathways

Submitted by:
Consortium Office

A Strategy and Results Framework for the CGIAR

For submission to the CGIAR Funders Forum

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Foreword

This document sets out the new Strategy and Results Framework (SRF) of the Consultative Group on International Agricultural Research (CGIAR). Developed at the level of the whole CGIAR system, the framework is a major outcome of the reform process that has been under way in the CGIAR since 2007. It is based on a first draft developed by the Strategy Team, which was first circulated and presented at the CGIAR's Business Meeting in Washington in December 2009, then revised through extensive consultations with the CGIAR centers and other partners, for discussion by a broader range of stakeholders at the Global Conference on International Agricultural Research for Development (GCARD), organized in Montpellier in March 2010. This new version represents further revisions and refinements following comments received at GCARD, at the informal donors meeting and the Joint Meeting of the CGIAR Alliance and Consortium that immediately followed GCARD and the Consortium Board Meeting in May 2010.

The SRF sets out the rationale and content for seven Thematic Areas of research to be undertaken by the CGIAR and briefly outlines the subdivision of these Thematic Areas into potential programs of research that will shape a series of megaprograms (MPs), which will be subject to performance contracts. It aims to maximize the positive impacts of the CGIAR's current and future research activities. Its context is one in which, while the relationships between funders and _donors' are maintained, their functions are more clearly demarcated, and in which the links and synergies between centers will be better orchestrated and work with external partners will be more efficiently integrated. This is expected to result in both operational and funding efficiencies, leading to greater confidence in the CGIAR's ability to rise to the unprecedented challenges posed by its mandate. This in turn should lead to increased funding to support the CGIAR's research, capacity building and communications activities.

GCARD 2010 fulfilled expectations in providing the perspectives needed from partners in order to refine the definitions of Thematic Areas, and to identify specific MPs, and components of Thematic Areas that potentially may be developed as MPs, based on the evaluation of the Consortium Board. The proposal was further refined in the discussions that took place in Montpellier during the meetings of the CGIAR Consortium Board and the Alliance of CGIAR Centers and following the Informal Donor Consultation Meeting. Additional comments were provided by the Consortium Board at their meeting in Rome (May 2010). In this draft we believe we have taken the proposal forward in a way that balances the need for integration and synergy with the need for managerial efficiency.

The main issues that remained outstanding after GCARD were the boundaries between the Thematic Areas and the level of integration between them. We have tackled these issues as best we can, although final decisions on the exact composition of each MP remain to be spelled out in the business plans that will be drawn up. One decision at Montpellier was to fast-track three MPs – and plans for these have been drawn up concurrently with the revision of this SRF document.

The SRF Process Team[1]

[1] Emile Frison (Chair), Fiona Chandler, Colin Chartres, Charlie Crissman, Ruben Echeverria, Shenggen Fan, Dave Hoisington, John McDermott and Wayne Rogers.

Message from the Alliance

The Alliance would like to express its thanks for the hard work done by the Strategy Team[2] in 2009 in creating the foundation for this new CGIAR Strategy and Results Framework. Through a long and sometimes arduous process they have created focus out of complexity; their hard work is greatly valued and appreciated. Many thanks are due also to the SRF Process Team appointed by the Alliance at its February 2010 meeting and to the numerous contributors from the Centers, who throughout the process have provided valuable feedback, analysis, corrections and information that have progressed the strategy further down the line towards becoming a workable, implementable plan. Their thoughtful and considered contributions are of crucial importance to the end result. We also appreciate the feedback received from the Fund Council members who agreed to act as a sounding board in the next steps of developing the SRF.

This document reflects comments made by stakeholders at the Global Conference on Agricultural Research for Development (GCARD), held in Montpellier in March 2010, and at the Informal Donors' Consultation Meeting and the Joint Meeting of the CGIAR Alliance and Consortium Board that immediately followed GCARD. This is the document we submit to the Consortium Board for review and final endorsement, before it goes forward to the Funders Forum for formal approval.

After approval by the Funders Forum of the SRF, Business Plans for those proposed MPs that satisfy the criteria set by the Consortium Board will be developed under the leadership of the Consortium Board and will be submitted to the Consortium Board for final approval and to the Fund Council, as they become available. Not all MPs will be developed at the same speed, as some will be more complex and will require consultation with a larger number of partners. In response to a request by the Fund Council, the Consortium Board decided to fast-track the development of three MPs for submission to the Fund Council during the summer. Others are expected to be submitted later in the year. We look forward to fruitful interactions with our partners during these final stages of refinement and approval of the MPs.

The creation of this document is a major building block in the new CGIAR that is now taking shape. We believe it to be key to realizing the shared commitment of the CGIAR and its partners so eloquently articulated at GCARD – not only to reduce hunger and poverty while protecting the environment but, ultimately, to eradicate them.

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Executive Summary

Overview

Global crises in food, finance, climate and the environment present well documented and growing threats to the lives and livelihoods of millions of poor people. The CGIAR group of international research centers and partners is ideally positioned to help address these challenges by means of coordinated, science-based, technological, institutional and policy approaches.

Its reputation for expertise and innovation in creating and facilitating ground-breaking technologies, exploiting vast germplasm resources, marshaling public and private research through a broad network of partnerships and pointing the way to policy and institutional innovations is strong, global and well-established.

The scale of the challenges, however, requires a redoubling of efforts. In response to this, the CGIAR has set out a new, results-oriented strategic framework: the Strategy and Results Framework (SRF). This provides an overarching structure for the combined work of its Centers that brings focus and efficiency to its research, steering it clearly towards system-level objectives and outcomes.

The result will be measurable enhancements of the CGIAR's contributions to reduced poverty, global food security and environmental sustainability.

The framework has been devised so as to most effectively channel the strengths and assets of the CGIAR by means of its improved organizational structure, while at the same time taking full advantage of the talents and opportunities available within the wider agricultural innovation system within which the CGIAR sits.

This new framework provides strategic direction, ensuring that the work of Centers and programs converges on the shared objectives of the CGIAR group, and produces measurable results that enable these objectives to be met. Its orientation to "results at scale" means that the drivers for planning will be real-world impacts rather than an internal focus, and that these impacts will be counted at every level, from system level down through research programs and projects and ultimately to the ground. Achieving this will draw upon a broad range of partnerships, not only in the research process, but also in subsequent stages of the impact pathway, to ensure that the research results lead effectively to impact.

The SRF applies to the CGIAR as a whole. It enables all of the CGIAR Centers, partners and donors to see how their efforts contribute to the overall vision of the CGIAR and how their work fits with that of other organizations in the system. Note that since it is a results-oriented *research system*—in contrast with, for instance, a results-oriented *development program*—it implicitly acknowledges the unpredictable outcomes of research undertakings. Freedom of research and space for "blue-sky" experimentation will therefore be maintained while respecting the requirement for research remits to be demand-driven.

Structure

The SRF is designed to provide strategic direction and a results-focus in order that CGIAR research:

- Enables progress towards the CGIAR Vision;
- Is focused towards the CGIAR system objectives (and by implication the MDGs);
- Delivers system-level results to enable the above.

Box A summarizes these terms.

Box A: Vision, objectives and results

The CGIAR Vision

The CGIAR vision is to ~~"~~reduce poverty and hunger, improve human health and nutrition, and enhance ecosystem resilience through high-quality international agricultural research, partnership, and leadership."

The CGIAR system-objectives

- Create and accelerate sustainable increases in the productivity and production of healthy food by and for the poor (Food for People).
- Conserve, enhance and sustainably use natural resources and biodiversity to improve the livelihoods of the poor in response to climate change and other factors (Environment for People).
- Promote policy and institutional change that will stimulate agricultural growth and equity to benefit the poor, especially rural women and other disadvantaged groups (Policy for People).

The SRF system-level results

In order that the Strategy and Results Framework (SRF) can enable the CGIAR to meet its system-objectives and achieve its vision, and in order that investors can know what returns they can expect, the SRF defines ambitious but realistic results on clear timelines.

These results will be achieved via the research outputs of the Centers and partners, (such as new crop varieties, improved policy instruments or optimized water use strategies). Their impacts will determine how and whether research is fulfilling requirements. When research outputs enable constructive change – or impact – that translates into measurable progress towards the global development goals encompassed in the CGIAR vision, then it can be seen that these outputs are making a clear contribution to the expected results at system level and that the SRF is fulfilling its purpose.

The SRF defines the system-level results as follows:

1. Lift productivity and reduce poverty. An annual increase in agricultural productivity by an additional 0.5 percent to help farmers meet the food needs of the future world population and to help reduce poverty by 15 percent by 2025, as part of an overall global agricultural R&D strategy.
2. Contribute to reduction of hunger and improved nutrition. A reduction of hunger and improved nutrition in line with Millennium Development Goal 1 (MDG 1) targets, cutting in half by 2015 (or soon thereafter) the number of rural poor who are undernourished, with a focus on contributing to a reduction in child under-nutrition of at least 10 percent.
3. Contribute to sustainability and resource efficiency: A reduction in the impacts of water scarcity and climate change on agriculture through improved land, agroforestry, forestry, biodiversity and water management methods that increase yields with 10 percent less water, reduce erosion, and improve water quality by maintaining ecosystem services.

The SRF provides the required combination of strategic direction and emphasis on results by means of structural components designed to organize the research activities and accountability structures of the CGIAR into a coherent whole. These components – Thematic Areas and Megaprograms – are supported by three proposed, new, cross-cutting initiatives that add value across the entire portfolio.

Thematic Areas and Megaprograms

For research to deliver the system-level results, it must be appropriately planned, organized and managed and monitored, in order to most effectively channel resources, energies and activities and make best use of the available strengths and assets of CGIAR Centers and partners, while retaining a focus on the overall system-objectives of the CGIAR.

To do this, the SRF specifies seven broad Thematic Areas of research, selected for their potential for organizing research so that it delivers the system-level outcomes of the SRF while maximizing effective coordination between the CGIAR Centers.

While they are distinct, the seven Thematic Areas are designed to form clusters of results-oriented innovation activities whose combined impact across the entire portfolio of Thematic Areas will be greater than the sum of impacts from individual activities, because of the gains from synergies and system-wide cooperation.

The Thematic Areas thus coordinate major research efforts reaching across the CGIAR Centers and their partners, and bring together relevant participants on all research-related activities ranging from bidding for funds, through planning, implementation, monitoring and coordinating to synthesizing outputs and communicating results.

The use of Thematic Areas as organizing structures is intended to introduce efficiencies, encourage cooperation and collaboration, reduce competition for resources and harness partnerships to ensure that major research outputs lead to the required outcomes and impacts.

Each Thematic Area subsumes major programs of research, which are termed Megaprograms (MPs). Most Thematic Areas have just one such program; the broader ones have several. It is at the level of the MP that research is planned, implemented, managed and budgeted for; each MP must have an associated business plan.

The preparation and definition of the MPs is an iterative process. Their ongoing development will provide significant additional information and the likely optimization of the overall results indicators in the process.

The proposed seven interlinked Thematic Areas and suggested MPs are listed in Table A.

Table A: the seven Thematic Areas and their Megaprograms

Thematic Areas and MPs	***Purpose***
Integrated Agricultural Systems for the Poor and Vulnerable MPs:	Research into resilient, diversified and more productive combinations of mixed crop/livestock, rangeland, aquatic and agroforestry systems, with three particular areas of focus reflected in three proposed MPs. Links to markets, often across zones, will be important in all cases.

Integrated agricultural production systems for dry areas *Integrated systems for the humid tropics* *Harnessing the development potential of coastal and aquatic agricultural systems for the poor and vulnerable*	
Policies, institutions and markets to strengthen assets and agricultural incomes for the poor *(Forming a single MP of same name)*	Research into institutional, policy and investment changes needed to enhance agricultural income opportunities for farmers, pastoralists and fisherfolk, with a focus on agricultural value chains; pro-poor growth; and institutions and governance for the poor.
Sustainable production systems for ensuring food security MPs: *Rice-based systems* *Wheat-based systems* *Maize-based systems* *Grain legumes* *Roots, tubers and bananas* *Dryland cereals* *Livestock and fish*	Research to develop sustainable and resilient productivity increases at the global and regional level as climates change and demands increase, including by accelerating the development and uptake of new varieties; conserving, characterizing and utilizing the world's collections of germplasm for targeting gene discovery; improving crop management and providing information and policy support for pro-poor and gender-sensitive impacts. This will focus on seven proposed production system-based MPs. Attention will also be given to cross-cutting research relating to the conservation and characterization of, and access to, genetic resources.
Agriculture for improved nutrition and health *(Forming a single MP of same name)*	Promoting, coordinating and undertaking cutting-edge research into the interactions between agriculture, nutrition and health, with the aim of reducing poverty and gender inequality, and improving the food, health and nutrition security of poor populations through enhanced policy and program effectiveness, improved food safety, water quality and better understanding and control of emerging and zoonotic infectious diseases.
Durable solutions for water scarcity and land and ecosystem degradation *(Forming a single MP of same name)*	Researching the complex interactions between soil, water, ecosystems and productivity; the implications of these interactions for livelihoods; and the role of policies and institutions, as well as farm-level practices, with the aim of harmonizing agricultural productivity and environmental sustainability goals to improve water, soil and biodiversity management and ecosystems services, and increase water and land productivity for crops, livestock, fish and agroforestry.
Forests and trees *(Forming a single MP of same name)*	Researching the technical, institutional and policy changes needed to address the growing risks from imbalanced land-use change, deforestation, loss of tree diversity and the resulting degraded ecosystem services. The aim is to help conserve, develop and sustainably use agroforestry and forests for humanity, to harness forest ecosystem services for sustainable development and the poor, and to increase biodiversity and carbon sequestration through avoided deforestation.
Climate change, agriculture and food security	Coordinated action to diagnose and analyze the directions and potential impacts of climate change for agriculture; to ensure the inclusion of the agriculture, livestock,

(Forming a single MP of same name)	forestry and fisheries sectors in climate change policies in ways that benefit the rural poor; and to identify and develop pro-poor adaptation and mitigation practices, technologies and policies for food production systems and rural livelihoods.

To make sure that results are delivered at scale, the SRF will also identify impact pathways and indicators for measuring the contributions of each research activity, MP and Thematic Area towards the system-level results.

Key to the success of all the MPs will be a strong focus on effective partnerships, acknowledging that they should be built right from the inception of research projects and should carry on through their implementation to outputs, outcomes and impact.

In addition to partnerships with research partners, productive collaborations with development partners along the impact pathway will also be identified and implemented, and steps taken to promote their contributions to the intended impact.

Cross-cutting system functions

In addition to the MPs, three cross-cutting initiatives are proposed: gender in agriculture; capacity strengthening, learning and knowledge sharing; and strategic planning and intelligence. The intention is that these will underpin, constructively influence and be integrated within the activities and goals of all the MPs.

The first two will also provide appropriate support for monitoring in their respective areas, enabling indicators relating to gender and capacity strengthening to be factored into measures of progress towards the system-level outcomes.

The system-level function for addressing *gender in agriculture* is currently the subject of a scoping study commissioned by the Consortium Board. The results of this study will further inform the most appropriate way for this cross-cutting system function to be implemented and to ensure the each MP will take into account the latest gender-relevant research results; best practices for sex-disaggregated data collection, analysis and reporting; related successes and failures in gender-responsive R&D are broadly shared and learned from, and the necessary partnerships are built for strengthening skills and capacities for gender-responsive technology development.

The function for *capacity strengthening, learning and knowledge sharing* is intended to help further the aims of each MP by facilitating close and intensive work with partners and prospective partners. Strengthening the R&D capacity of all these partners, particularly the weaker national partners including National Agricultural Research Systems (NARS), will be a core function of the CGIAR. It is proposed that this is delivered primarily through the MPs, with capacity strengthening forming an integral part of the business plans of each MP. This activity will be enhanced by the support of a dedicated unit at the system level that will serve MPs, Centers and partners. It will use its system-wide perspective to develop and support global agricultural research networks through which the CGIAR and all the MPs can help stronger national systems contribute to the development of weaker ones.

The third proposed cross-cutting function in the SRF, for *strategic planning and intelligence*, will deliver urgently needed improvements in the quality, timeliness, transparency and objectivity of strategic, system-level programmatic and investment decisions, including the design and maintenance of a balanced, effective and efficient CGIAR R&D portfolio.

It will build on and formalize the CGIAR's existing knowledge bases and experiences into a new, cross-center facilitation mechanism to offer a strategic, forward-looking, R&D evaluation capacity and facilitate system-wide priority setting, targeting and investment decision-making based on supporting evidence.

Resources

Investment in agricultural research must increase substantially if its results are to make a sizeable impact on poverty and hunger.

To achieve a food-secure world by 2025, an annual increase in agricultural productivity of 0.5 percent across all regions until that year is required. This equates to a massive expansion of investment in agricultural research for development above current levels – from US$ 5.1 billion per year today to US$ 16.4 billion per year by 2025.

As well as investing more, it is also important to increase the efficiency of research and development and to target investments more effectively. If all three things are achieved, they will result in a substantial impact on not just food security but also on the numbers living in poverty (defined as an income of US$1.25 a day or less), which could be reduced by 401 million people by the same year for that same investment.

This increase includes the investment needed in national as well as international public-sector research. Investment in international public goods research is currently about 10 percent of total public R&D spending (slightly over US$ 500M in 2009). Making the conservative assumption that this will at least be held constant, and extrapolating it to 2025, we can propose that a CGIAR budget of US$ 1.6 billion (10 percent of US$ 16.4 billion) by 2025 is required if it is to make the appropriate contribution to food security and poverty reduction by that year.

This budget will need to increase substantially and incrementally, starting well before that date, if the outcomes and impacts proposed in this SRF are to be achieved.

Note that while the investments will be spread across the selected Thematic Areas, a large share of these will further develop the traditional CGIAR areas of strength (crop and animal productivity and natural resources management); there will also be an augmented focus on results at the level of poor people and communities.

Implementation and management

The implementation of the SRF and the development of the MPs within the respective Thematic Areas will be undertaken by the CGIAR Centers in collaboration with their partners. The CGIAR Consortium Board will oversee the coordination of the MPs and the delivery of system-level outcomes (based on the SRF). The Consortium will not manage individual MPs; instead one or more Centers of the Consortium will be made accountable for delivering on the results for each MP.

To effectively deliver on the Thematic Areas, participating Centers will require some institutional support, especially in maintaining Center infrastructure. Consortium-based units will also coordinate supporting functions for gender, capacity strengthening and forward-looking strategic planning.

Note that the CGIAR Centers tasked with delivering on the SRF and MPs may also pursue other aspects of their strategic agendas, as long as these activities do not undermine the capacity of Centers to deliver on the SRF and are executed with full cost coverage from other funding sources.

Detailed proposals with business plans for the implementation of each MP will be developed once lead Centers are identified for the task. Outlines for the scope of each Thematic Area appear in this strategy and serve as the basis for the suggested MP proposals.

Once the MP proposals have been approved by the Fund Council, the Consortium Board and the Fund Council must manage an orderly transition of funding from the current unrestricted funding to Centers to MP funding. The Centers must adjust research directions and partnership arrangements that will enable existing contracts operating under bilateral funding to be wound down over an appropriate timescale and current Systemwide and Challenge Programs to be integrated, where appropriate, into the MP portfolio of research. Decisions about existing research programs will be made on a case-by-case basis according to their ability to contribute to the outcomes required by the SRF. (Most of the Systemwide and Challenge programs are expected to contribute significantly to MPs.) More detailed suggestions for making these decisions are laid out in the SRF.

1. The Global Food and Agriculture System and the CGIAR

Introduction

The Consultative Group on International Agricultural Research (CGIAR) is facing immense challenges and immense opportunities. Global food insecurity has increased and under-nutrition remains stubbornly entrenched among many of the world's poorest people. Global economic growth and population growth have increased the pressure on food supplies. Natural resources are overstretched. And climate change imposes new stresses on natural resources, agriculture, and health and safety, especially among the poor. The commercial pressure on land and water resources is increasing and conflicts over these are spreading, with poor communities' rights often going unprotected.

The CGIAR is well positioned to help overcome these challenges. After nearly two decades of neglect, the role of agriculture and agricultural research in reducing poverty is once again receiving high-level political recognition. The World Bank *World Development Report 2008*,[3] policy statements from the United Nations, the Groups of Eight and Twenty (G8 and G20), the European Union, the United States, China, and the African Union, among others, and numerous reports from other institutions,[4] are focusing attention on issues close to the heart of the CGIAR. The time is ripe to develop further a truly global agricultural research effort, drawing on existing resources in the CGIAR and its partnerships to build increased support for their mission.

As a key component of the international agricultural research system, the CGIAR has contributed mightily to innovations that have led to increased food production and availability and improved natural resources management, with the benefits flowing largely to poor people. But the context in which it operates – of R&D in world agriculture – is changing. Private sector research is playing a growing role. Although very limited research capacity is still common in many low-income countries, some large national research systems, especially in Brazil, China and India, have made rapid advances, enabling them to play a leading role. The new challenges already mentioned require new and increased R&D attention, while science itself is presenting new opportunities. The CGIAR is re-examining how it does business in this changing environment.

The CGIAR has thus embarked on a process of reform designed to create a more coherent program, with a new Strategy and Results Framework (SRF) to help it more effectively meet current and emerging research and development challenges. Rising to these challenges will

[3]. World Bank, World Development Report 2008: Agriculture for Development (Washington, DC, 2008).

[4] International Assessment of Agricultural Knowledge, Science and Technology for Development, Agriculture at a Crossroads (Washington, DC: Island Press, 2009); Intergovernmental Panel on Climate Change, IPCC Fourth Assessment Report: Climate Change (Cambridge: Cambridge University Press, 2007); Millennium Ecosystem Assessment, in the four volumes in its Ecosystems and Human Well-Being series (Washington, DC: Island Press, 2005); D. Molden, ed., Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture (London: Earthscan, 2007).

require a sizeable increase in funding, and the SRF sets out a structure that shows how additional resources would be channeled to maximize the returns to investment.

The strategy presented here is for the CGIAR as a whole. As far as possible, it has been developed on the basis of evidence, not opinion – however well articulated. This evidence includes the use of models, which were important in projecting the demand for food and other commodities and so in identifying major research needs, and many sources of information and advice, all of which are made transparent. It was assumed that investors wanted to hear first from the research communities about what and where the strategic R&D investment opportunities are. If need be, this approach will also allow hard choices under budget constraints to be made more rationally.

The Context of the Strategy

The CGIAR has developed its SRF in the context of persistent poverty, mounting food insecurity and deteriorating natural resources, coupled with a renewed commitment to solving these problems through extended partnership. In 2009 more than 1 billion people around the world suffered from chronic or acute hunger and under-nutrition caused by diets deficient in human nutritional requirements including micronutrients; that number may double when hidden hunger is taken into account.

Agriculture is key to reaching development goals

The livelihoods of millions of smallholders and rural people depend directly on their ability to grow, harvest, process and market crops, livestock, fish, tree and forest products. The indirect effects of agricultural[5] growth and ecosystems services on incomes and jobs, on consumers' nutrition and health, on educational prospects, on social and cultural development, and on the environment, are even larger. Agricultural growth in developing regions thus remains fundamental for poverty reduction and food security. In many countries, the targets associated with the first of the Millennium Development Goals (MDGs), to halve poverty and hunger by 2015, will not be reached. If poverty and hunger are to be eradicated in the longer term, substantial investments must be made in agricultural research and innovation as well as in agricultural development. The SRF reflects the opportunities that agriculture presents for pro-poor economic development and the contribution that a well-functioning food and ecological system can make to human wellbeing and security.

Improved agriculture and natural resource management have crucial roles to play with regard to other development goals, including the MDGs related to achieving greater environmental sustainability (MDG7), improving access to water (MDG7c), overcoming land degradation (MDG7a), promoting gender equality (MDG3), reducing child mortality (MDG4) and improving maternal health (MDG5).

Agricultural research must investigate how best to manage the scarce resources that contribute to reductions in hunger and poverty, including water, soils, biodiversity, forests and fisheries. Climate variability and change are making poor producers increasingly vulnerable to losses and damage, so research on how to adapt agricultural systems and how to mitigate climate change is

[5] Here and throughout this document, unless otherwise specified, we define agriculture broadly to include the livestock, fisheries, forestry and agroforestry sectors alongside crop production, and urban production alongside rural.

essential. Innovative, integrated approaches and systems-focused programs are needed to address these issues.

Most important, agricultural research must take advantage of opportunities to improve the yields of food and other products through cutting-edge science. Advances in such areas as biotechnological tools including genomics, information technology, functional diversity, geographic information systems and nanotechnology can increase and sustain the productivity of the main crop, animal, fish and tree commodities produced and consumed by the world's poor. Programs on sustainable productivity increases and on agricultural systems for global food security are needed to embrace these issues.

Agriculture has considerable potential to affect health – negatively, through the prevalence of food-borne contaminants (such as aflatoxins), and positively, through improved nutrition (for example, through biofortification and diversified diets). Agricultural systems themselves can threaten the health of rural and urban people, for example through pesticide misuse, the spread of zoonotic diseases, or the creation of breeding habitats for disease vectors. The multiple links between health and agriculture demand research in pursuit of improvements in human and animal health and nutrition. A program on agriculture, health and nutrition is needed to address this challenge.

Meeting these development challenges requires a focus on empowering women to grasp opportunities for improving their livelihoods and those of their families. Women play an increasingly significant role in agriculture, being responsible for approximately 50% of all production. The CGIAR recognizes this role and is committed to increasing its efforts to orient research and to change farming practices and systems so that women can play an important part in enhancing agriculture productivity and improving their livelihoods. It is also committed to influencing governance systems so that these include women in decision-making.

Multiple challenges

Challenges to overcoming poverty and food insecurity and achieving sustainable management of natural resources arise on several fronts. Decades of underinvestment in agricultural research and innovation have reduced productivity growth. Annual growth in cereal yields worldwide has declined from about 3 percent in the 1960s and 1970s to less than 1 percent since 2000. In 2007 and 2008, high prices and favorable weather encouraged agricultural expansion in developed countries, but production in developing countries failed to take off. Cereal output grew by 11 percent in developed countries between 2007 and 2008 but by only 0.9 percent in developing countries. If Brazil, China and India are excluded, cereal production in the rest of the developing world actually fell by 1.6 percent.

The recent food and financial crises have serious implications for food and nutrition security in developing countries. In 2007 and 2008, the price of nearly every agricultural commodity rose sharply, creating a global food price spike. Several factors contributed to these price increases: increasing frequency and severity of drought, rising energy prices and subsidized biofuel production, income and population growth, and market and trade policies that had a distorting effect. Although prices have since fallen somewhat, they remain high by recent historical standards, as do critical price ratios such as those between crops and fertilizers. Increased volatility and risk look to remain lasting features of the world food system, requiring urgent attention from planners and policy makers in addition to researchers. Poor people spend 50–70

percent of their income on food. Because wages for unskilled labor tend not to rise in line with food inflation, the poor have little capacity to adapt as prices rise. Moreover, even before the recent food crisis, the poorest of the poor were being left behind. Programs to address production and productivity through policy and institutional innovations, improved markets and market linkages for smallholder agriculture are needed.

At the same time, the natural resources on which agriculture depends are under stress. Global economic and population growth have combined to increase pressure on water, arable land and forest products, including wood fuel for cooking. Climate variability and change will further threaten agricultural productivity and production by increasing the risk of droughts and floods, affecting temperatures and crop growing seasons, altering the distribution of pests and diseases, and triggering rises in sea levels as well as changes in the ability of the oceans to support life. Many of the world‘s fisheries are already near collapse. Genetic erosion undermines efforts to improve crops and livestock. It is no exaggeration to say that natural resources depletion and degradation threaten the very future of civilization, in addition to global food security and the global economy. Different regions face different challenges: in sub-Saharan Africa, poverty and food insecurity persist and are even worsening in some countries; much of Asia and Latin America have benefited from rapid economic growth in recent decades, but inequality remains a serious problem, with gaps between rich and poor widening; the dry areas of North Africa and South, West and Central Asia confront particularly serious water scarcity issues (see Figure 3.7 later in this document), likely to be exacerbated by climate change. Competition for access to productive resources has been recognized as a source of increasing conflicts. To combat these problems, the CGIAR Centers and their partners must increase their focus on improving the sustainable use of land, water and genetic resources, in addition to investigating the adaptation of crops and livestock to drought, heat and other stresses. Policies and institutions must be put in place that recognize the importance of agroforests and forests in minimizing soil erosion and soil fertility decline and in protecting water quality while assuring stable water quantity. Agricultural systems must be harmonized with the ecosystem services provided by a healthy landscape. To achieve sound outcomes, considerable effort will also be needed to instigate the policy and institutional innovations that will lead to land management changes. Research programs on climate change, on forests and trees, and on water, soils and ecosystems are needed to address these challenges.

The CGIAR‘s strategic approach and research agenda will ensure a balanced approach in which productivity- and sustainability-oriented approaches to agricultural development go hand in hand.

Multiple opportunities

On the positive side we note the prospect of rapid progress and new developments in basic sciences relevant to agriculture (including biotechnology, information technology, functional diversity, geographic information systems and nanotechnology) and new expressions of political will for change.

The international community has made repeated commitments to eradicating global poverty and hunger, most recently in response to the food crisis of 2007–2008 but also predating this. In 2008, the United Nations assembled a High-Level Task Force on the Global Food Crisis, which developed a *Comprehensive Framework for Action* that represents the consensus view of the UN system on how to respond to the food crisis. Promotion of smallholder food production plays an

important role in this framework.[6] The G8 countries together with others issued a statement in July 2009 to the effect that "there is an urgent need for decisive action to free humankind from hunger and poverty ... We therefore agree to act with the scale and urgency needed to achieve sustainable global food security. To this end, we will partner with vulnerable countries and regions to help them develop and implement their own food security strategies, and together substantially increase sustained commitments of financial and technical assistance to invest in those strategies."[7] This statement, which specifically supports reform of the CGIAR, was later affirmed by the G20 and signed by 36 nations and UN agencies. African leaders have made a new commitment to invest in agriculture and pursue agricultural growth through the Comprehensive Africa Agriculture Development Programme (CAADP). Agricultural R&D is an important pillar of CAADP and will be strongly promoted by the Forum for Agricultural Research in Africa (FARA) and the Alliance for a Green Revolution in Africa (AGRA). In at least some donor countries, foreign aid has been ring-fenced by governments mindful of the public outcry against poverty and hunger in the mid-2000s and the ongoing campaign to "make poverty history".

Various international agreements protect the access to and use of the genetic resources that must underpin these renewed commitments to end hunger and poverty. The International Treaty on Plant Genetic Resources for Food and Agriculture, which came into force in June 2004, creates a legal and administrative framework for an international pool of plant genetic resources in support of breeding, research, and sustainable use. Ongoing negotiations under the Convention on Biological Diversity and the Commission on Genetic Resources for Food and Agriculture present similar opportunities for animal, microbial and tree genetic resources.

Capturing the opportunities implicit in these international undertakings will require sustained political will in support of agricultural development together with a strong systems approach to work on the ground. Programs on agricultural systems for the poor and vulnerable, which include crops, trees, livestock and fisheries, together with appropriate policy and institutional research, will need to be centerpieces of the CGIAR's new strategy.

In seeking to reduce persistent poverty and hunger the CGIAR thus faces a daunting task, but it does so in a setting in which the value of agricultural research and development are increasingly recognized, making it easier to form the partnerships and marshall the resources necessary for success.

The role of the CGIAR in the global research system

Since the 1970s, CGIAR Centers have contributed to increased agricultural production in developing countries through innovative research that was beyond the capabilities of national agricultural research systems and unlikely to be undertaken by the private sector. Today, the situation is changing rapidly. National systems in Brazil, China and India undertake advanced

[6] United Nations, High-Level Task Force on the Global Food Security Crisis, "Comprehensive Framework for Action" (New York, 2008).
[7] Group of Eight, "L'Aquila Joint Statement on Global Food Security," July 10, 2009, http://www.g8italia2009.it/static/G8_Allegato/LAquila_Joint_Statement_on_Global_Food_Security[1],0.pdf.

agricultural research while private sector investment in research of relevance to developing country agriculture has grown enormously.

Nonetheless, the CGIAR has a unique role to play in this changing context. Neither national research systems nor private companies can be expected to provide international and global public goods in the areas of agricultural research and environmental sustainability – goods that have the ultimate goal of eradicating poverty and hunger worldwide. In the parts of the world where the poorest people live, private sector products and technologies are for the most part unavailable and national agricultural systems still tend to be weak. Yet meeting international targets for poverty and hunger reduction require more attention to just such areas and people. The CGIAR has a crucial role to play in generating and freely disseminating knowledge and technologies with wide applicability and in maintaining and making available genetic resources held in trust for the world – global public goods that can reduce poverty and enhance ecological sustainability. It is well placed to deliver these goods to a range of actors worldwide who can use them effectively.

As the CGIAR turns to the task of creating a SRF that will carry it forward in the 21st Century, it can build on its past impacts and historic strength in key areas (see Box 1), in addition to its current core assets and comparative advantages. Within the international agricultural research system, the CGIAR is widely recognized as having a number of core assets:

- A group of 64 member countries and organizations committed to addressing global development challenges through international agricultural research
- A critical mass of scientists with multidisciplinary knowledge of key agro-ecosystems
- An extensive global research infrastructure, including research stations representing many agro-ecosystems
- Global and regional research networks with strong links to national agricultural research and innovation systems
- Global collections of genetic resources held in trust for the world
- A reputation for being an ~~"h~~onest broker," acting in the interests of the world's poor in the global science and policy-making communities.

Box 1. The CGIAR's track record in improving the livelihoods of the poor

Since its foundation in 1971 the CGIAR has been associated with some phenomenal successes – notably the large increases in the productivity of Asian cereal systems associated with the Green Revolution. Global and regional evaluations suggest that investments in the CGIAR have paid for themselves by a wide margin, generating impacts worth hundreds of billions of dollars and providing rates of return well in excess of 40 percent. Considerable evidence also points to large pro-poor impacts of international agricultural R&D.

Principal outputs of CGIAR research have included improved crop varieties and associated knowledge. These outputs have contributed to substantial outcomes: more than half of the improved varieties grown in Africa, Asia and Latin America contain germplasm originating from CGIAR research; there is also widespread use of CGIAR knowledge products, including tools for participatory analysis of local governance systems, spatial mapping of land and water resources, and new poverty maps for informing national strategies.

The successes of crop genetic improvement have been widely documented. The yield-enhancing and yield-stabilizing modern varieties produced by the Centers and their partners have had – and continue to have – large direct impacts on productivity and equally large indirect impacts on wages and prices, generating substantial and lasting benefits to poor people both within and outside the agricultural sector. Investments in the CGIAR to 2000 have increased cereal yields by 0.7–1.0 percent annually, reduced world grain prices by about 20 percent, and prevented 13 million to 15 million children from being malnourished. Substantial benefits in particular have arisen from productivity improvements in rice and wheat and from the bio-control of the cassava mealybug. Impacts in sub-Saharan Africa had been lower than in other regions, but there have been notable recent successes in maize, cassava, beans, cowpea and potatoes.

Assessments of CGIAR research on pest management reveal substantial positive impacts of research on biological control (particularly in Africa), pest-resistant varieties, and localized successes in integrated pest management. Research on natural resources management tends to have more local impacts, although there are notable successes at the regional level, such as the adoption of conservation farming, agroforestry practices, improved aquaculture and sustainable forestry management guidelines. Policy-oriented research has also affected large numbers of people at the country level through, for instance, improved policies on prices and marketing, pesticide regulation and control, policies to encourage smallholder dairy production, and policies to reduce deforestation and enhance smallholder agroforestry. Policy research has also had an impact at the global level through, for instance, research on trade and public investment strategies.

International research generates spillover knowledge relevant to countries other than those where the research takes place and has nonmarket environmental benefits that are often underestimated. It may have some of its greatest impacts on the global policy agenda: cases in point are the timely analysis of the 2008 global food crisis and ongoing strategic inputs to the International Treaty on Plant Genetic Resources for Food and Agriculture.

These diverse successes highlight the importance of a wide-ranging portfolio of research investments, given that real-world outcomes from individual research endeavors are inevitably uncertain.

Sources: CGIAR System-wide External Review, 2008, and documents of the CGIAR Standing Panel on Impact Assessment.

These core assets point to the CGIAR's comparative (and complementary) advantages, which lie principally in:

- Conducting agricultural research for development
- Conserving, evaluating and making available the genetic diversity of the world's major crops and related knowledge
- Catalyzing technological, policy and institutional innovations
- Raising awareness, of both current and future challenges to agricultural development
- Creating and sustaining partnerships and networks, at the local, regional and international levels

- Supporting policy making and decision making
- Strengthening research capacity, and
- Catalyzing North–South and South–South collaboration

The CGIAR has a particular role to play in strengthening weaker national partners so that they can participate effectively in global agricultural research and innovation systems, in building and supporting international research networks, and in developing effective partnership models with civil society and private sector investors. The CGIAR's enduring value as catalyst, facilitator and leader of international public goods research in agriculture continues, but to deliver outcomes effectively and efficiently it must now build even stronger partnerships with the other actors in the changing global food and agriculture research system.

2. Towards a Strategy and Results Framework

Given the broad scope of its agricultural research capacity and its strong international networks, the CGIAR is well placed to address the global nature of today's agricultural research challenges. It can and should play a central role in the global research system.

To help it meet the challenges of the coming decades, the CGIAR has undertaken a broad review and consultation process to develop this SRF. The outcome of this process is not just a set of future research programs but an approach to addressing current and emerging challenges in ways that produce measurable results for human wellbeing. The SRF will also provide strategic inputs to the activities of development agencies at the international and national levels.

The Starting Point: A New Vision

Strategic planning for the CGIAR began in 2008, when the CGIAR developed a new vision,[8] as follows:

> *To reduce poverty and hunger, improve human health and nutrition, and enhance ecosystem resilience through high-quality international agricultural research, partnership, and leadership.*

The CGIAR, along with partners, stakeholders, and potential beneficiaries, will work towards the realization of this vision. The CGIAR will pursue this vision through three strategic objectives[9]:

- Create and accelerate sustainable increases in the productivity and production of healthy food by and for the poor (Food for People).
- Conserve, enhance and sustainably use natural resources, including biodiversity, to improve the livelihoods of the poor in response to climate change and other factors (Environments for People).
- Promote policy and institutional change that will stimulate agricultural growth and equity to benefit the poor, especially rural women and other disadvantaged groups (Policies for People).

These strategic objectives spring from a recognition that the CGIAR must focus directly and indirectly on sustainable development and on the wellbeing of people, in particular the poor and marginalized, and especially women. They were designed to address the key development

[8] CGIAR Working Group on Visioning, "Visioning the Future of the CGIAR," Report to the Executive Council (Washington, DC, CGIAR, 2008).

[9] In the terminology of Analytical Hierarchy Processes and Planning Programming Budgeting Systems, a higher-level goal is pursued through subgoals (or strategic objectives), subgoals are pursued through lower-level goals, and so on. By definition, all subgoals (and lower-level goals) are instruments for achieving the next higher level goal(s) and, ultimately, the top goal (in this case, the CGIAR vision).

challenges for which the CGIAR has a comparative advantage. They can be achieved only with the help of partners in the public and private sectors and through supportive government action.

For the CGIAR to have impact, its vision and strategic objectives must be transformed into a set of measurable outcomes that contribute explicitly alleviating poverty and hunger, supported by healthy and resilient ecosystems. Given that the CGIAR is primarily a research organization, its SRF must take into account the characteristics of research, especially the unpredictability of success and the need to make potentially high-impact but also high-risk and long-term R&D investments. Applying the concept of results-oriented planning to research investment involves providing creative space for researchers – typically best achieved in a flexible, decentralized research system in which decision making powers are delegated to the lowest effective level.

From Vision to Strategic Outcomes

To develop this SRF, the CGIAR adopted the approach of ―managing for results" – a business concept that has been taken up by the public sector in a number of realms, including international development.[10] The Independent Review of the CGIAR System,[11] completed in 2008, highlighted the advantages of this approach for the CGIAR. The idea is to manage and implement investments in a way that focuses on the results desired and uses information on progress towards these results to improve decision-making. According to the review, managing for results is ―a coherent framework for strategic planning, management, and communications based on continuous learning and accountability." Such an approach requires:

- A results-oriented strategy that sets directions and outcomes
- Management decisions and resource allocations that align with strategic outcomes
- Program performance indicators that target clients and beneficiaries and measure improvements in the livelihoods of beneficiaries; and
- Indicators that are used as signals to motivate staff and provide a base for learning and improving.

Agricultural research undertaken by the CGIAR and its partners generates *outputs*, such as improved crop varieties, policy instruments, pest management strategies or water use strategies. Uptake of these outputs by targeted end users generates *outcomes*, such as increased agricultural production, lower food prices or more efficient production systems. These outcomes lead to *impacts* on ultimate beneficiaries, in the form of improved food security, livelihoods, and health and other benefits, including more choice and more power over their lives. See Figure 2.1.

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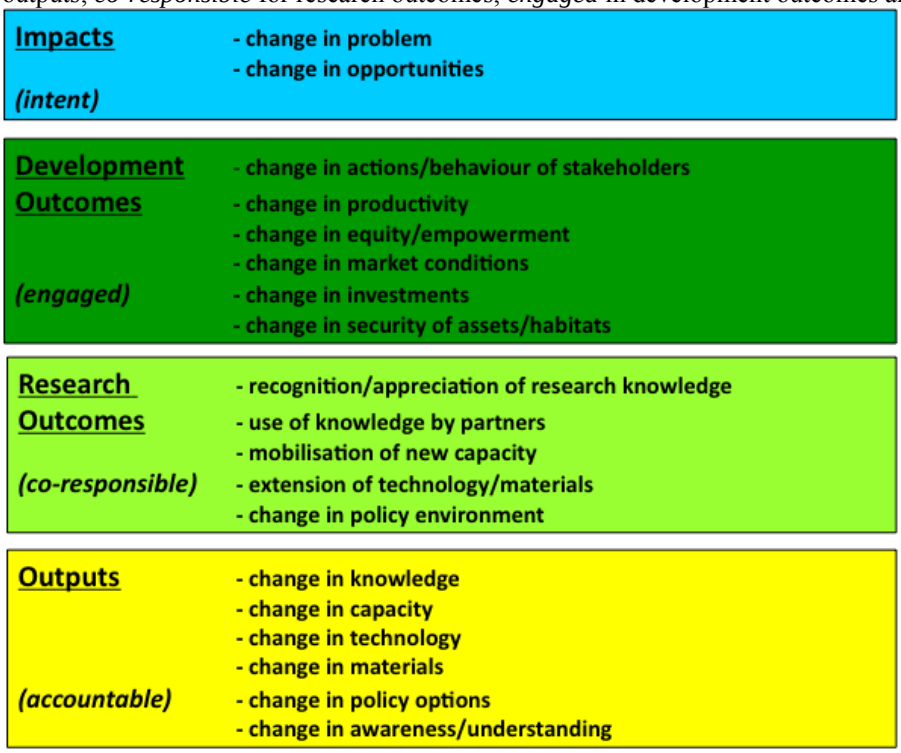
[10]. The Paris Declaration on Aid Effectiveness, for example, has established managing for results as one of five mutually reinforcing pillars. Results-based management emerged from initiatives of CIDA and others. Some useful websites are:

www.idrc.ca/en/ev-88062-201-1-DO_TOPIC.html; http://ceb.unsystem.org/documents/FB.reports/dacrbm.pdf
www.oecd.org/dataoecd/17/1/1886527.pdf; www.oag-bvg.gc.ca/domino/other.nsf/html/00rbm_e.html
www.unfpa.org/**results**/docs/rbminfomaterials.doc

[11] CGIAR Independent Review Panel, ―Bringing Together the Best of Science and the Best of Development," Independent Review of the CGIAR System, Report to the Executive Council (Washington, DC, 2008).

Figure 2.1: How impacts are driven by outputs and outcomes

(Note: the bracketed words describe the CGIAR's involvement in each level – i.e. it is *accountable* for producing outputs; *co-responsible* for research outcomes; *engaged* in development outcomes and *intends* to produce impacts.)



The transition from agricultural research to outputs, outcomes and impacts – the impact pathway of research – is not always direct or smooth. Research that delivers substantial benefits in terms of international public goods is often risky, with results that are unpredictable. Flexible resource allocation and long-term investment are needed to allow for the process of trial and error that will lead to significant outputs. And the investment must be on a large enough scale to allow a high chance of success. Room must be made for exploratory ~~"b~~lue-sky" research at one end of the spectrum; while at the other, local research to adapt outputs to local conditions and needs will be essential. This is a major argument in favor of CGIAR researchers' working closely with partners in government and civil society to support the application of international public goods.

In identifying the outcomes for the SRF, we were mindful of the CGIAR vision: ~~"t~~o reduce poverty and hunger, improve human health and nutrition, and enhance ecosystem resilience through high-quality international agricultural research, partnership, and leadership." The ideas underpinning the vision have already been framed as outcomes in the form of the MDGs. In particular, MDG 1 sets targets for poverty and hunger reduction, while MDG 7 states that sustainable growth requires the protection of ecosystems and ecosystem services.

To investigate how different aspects of agricultural research can contribute to outcomes like these, a variety of possible policy and investment scenarios were analyzed, primarily using the Integrated Modelling Platform for Animal Crop Systems in the Tropics (IMPACT), a modeling

tool developed by the International Food Policy Research Institute (IFPRI).[12] The scenarios use several combinations of factors, including investments in agricultural R&D, efficiency of agricultural R&D, investments in irrigation, changes in natural resource management, and changes in agricultural marketing. More specifically:

- Scenario 1a is an increased agricultural research investment scenario that assumes a 60 percent increase in the growth rates of crop yields, across all crops, and 30 percent increase in the growth rates of livestock production, over a baseline extrapolated from current trends
- Scenario 1b is the same as Scenario 1a, but with added emphasis on investment in agricultural R&D in South Asia and sub-Saharan Africa
- Scenario 2 combines improved natural resources management with enhanced market efficiency
- Scenario 3 is a comprehensive scenario that combines increased investment with more efficient research, expanded irrigation infrastructure, improved natural resources management and enhanced market efficiency

The model produces projections in the production and prices of various commodities for these scenarios, extending to 2025 and 2050. The alternative policy and investment scenarios overlay a baseline that assumes a continuation of current trends in population and agricultural and economic growth and that postulates moderate climate change through 2050. For each scenario, changes in yield, total production (crops and livestock), world prices, trade and child malnutrition are presented for 2025.[13]

Table 2.1 shows changes in production and prices for important crop and animal products under the four scenarios that inform the results focus of the strategy. The different scenarios also have implications for nutrition, as shown in Table 2.2.

[12] Here only an overview is given. IMPACT has 115 countries (or in a few cases country-aggregate regions), within each of which supply, demand and prices for agricultural commodities are determined. Large countries are further divided into major river basins. World agricultural commodity prices are determined annually at levels that clear international markets. Growth in crop production in each country is determined by crop and input prices, exogenous rates of productivity growth and area expansion, investment in irrigation and water availability. Demand is a function of prices, income and population growth and contains four categories of commodity demand – food, feed, biofuel feedstock and other uses. For details of results and model design, see report by Rosegrant et al. (2009) on the Alliance website.

[13] For the results on 2050, see background paper on Alliance website

Table 2.1. Production and price changes under various investment and policy scenarios, 2025

Commodity	Scenario 1a	Scenario 1b	Scenario 2	Scenario 3
	(% change in production in developing countries from baseline scenario)			
Rice	3.8	5.0	5.2	10.7
Wheat	5.0	5.2	7.4	13.2
Maize	3.7	2.4	4.8	9.4
Groundnut	6.0	7.7	4.8	12.0
Cassava and other roots and tubers	8.1	11.2	4.8	14.8
Vegetables	9.2	11.2	5.3	17.2
Beef	4.8	5.5	5.0	13.1
Poultry	5.3	6.2	4.1	12.4
	(% change in world prices from baseline scenario)			
Rice	–7	–10	–4	–13
Wheat	–12	–15	–4	–17
Maize	–18	–24	–3	–22
Groundnut	–14	–17	–5	–20
Cassava and other roots and tubers	–21	–28	–2	–24
Vegetables	–10	–12	–1	–14
Beef	–5	–6	–1	–9
Poultry	–7	–8	–1	–10

Source: IFPRI IMPACT, Rosegrant et al. for Strategy Team, 2009. See Alliance website for full report.

Overall, Scenario 3, the comprehensive scenario, achieves the largest yield production increases for farmers and hence the greatest reductions in prices and childhood malnutrition. These figures point towards the scale of investments needed to achieve real progress in alleviating poverty and hunger, and in turn towards the kinds of research needed and the outcomes such research should seek to achieve. (It is acknowledged that an efflux to off-farm or out-of-landscape employment must still play a major part in rural poverty alleviation if overall smallholder farmer incomes are not to decrease, given the drop in market prices.)

An important feature of this modeling exercise is that it allowed us to study the distinct yet complementary contributions of increased agricultural productivity (~~–i~~nvestment in agricultural R&D" and ~~–e~~xpanded irrigation infrastructure"), improved policies (~~–e~~nhanced market efficiency" and ~~–m~~ore efficient R&D"), and improved natural resources management. All of these areas are demonstrably improved by agricultural research, and the CGIAR has a strong track record in delivering in all of them (see Box 1).

Table 2.2. Child malnutrition under various investment and policy scenarios (millions of children), 2025

Region	2005	2025 baseline	Change from baseline scenario			
			Scenario 1a	Scenario1b	Scenario 2	Scenario 3
South Asia	75	70	–2	–3	–2	–4
East Asia and the Pacific	23	18	–2	–2	–1	–3
Eastern Europe and Central Asia	4	4	0	0	0	0
Latin America and the Caribbean	8	8	–1	–1	–1	–1
Middle East and North Africa	3	3	0	0	0	–1
Sub-Saharan Africa	39	49	–4	–5	–3	–7
Developing countries	152	152	–9	–12	–7	–17

Source: IFPRI IMPACT, Rosegrant et al. for Strategy Team, 2009.
Note: The 2025 baseline scenario is with climate change.

Although increasing agricultural productivity (Scenario 1) makes the largest contribution in terms of reducing the price of staple crops, the other scenarios also make significant contributions, and the effect of all factors is usually greater than the sum of the parts when it comes to improving rural livelihoods.

This evidence from predictive modeling forms the rationale behind the three proposed system-level outcomes for the SRF, which also reflect the structure of the MDGs[14]:

1. *Lift productivity and reduce poverty*: An increase in annual agricultural productivity of an additional 0.5 percent to help farmers meet future food needs and reduce poverty by 15 percent by 2020
2. *Reduce hunger and improve nutrition*: A reduction of hunger and an improvement in nutrition in line with MDG 1 targets, halving by 2015 (or soon thereafter) the number of rural poor who are undernourished, with a focus on reducing child undernutrition by at least 10 percent.
3. *Contribute to sustainability and resource use efficiency*: A reduction in the impacts of water scarcity and climate change on agriculture through improved land, biodiversity, agroforestry, forestry and water management methods that increase yields with 10 percent less water, reduce erosion and improve water quality by maintaining ecosystem services.

[14] These three system-level results criteria capture the relevant outcomes related to the strategic objectives and partly cut across the strategic objectives; separate, specific outcomes are also defined for the MPs.

From Outcomes to Thematic Areas and Megaprograms

Using the three system-level outcomes as points of departure, we then faced a twofold challenge: to identify the broad Thematic Areas on which research should focus and, within these, to delineate programs of research – megaprograms (MPs) – that would collectively achieve the outcomes.

Our underlying assumption, in meeting this challenge, was that the CGIAR can achieve the greatest impact by integrating research to increase productivity, improve natural resources management, and bring about institutional and policy change. The validity of this assumption is amply demonstrated by the CGIAR's experience over the past 20 years and by recent CGIAR impact assessment in each of these areas (see Box 1). It is further supported by the IMPACT modelling exercise described earlier, which shows that the different scenarios – enhancing agricultural productivity, improving natural resources management, and increasing market access – have a more than additive impact on reducing hunger and poverty.

Maximizing impact on poverty and hunger

We then set out to determine how research into productivity, resource management and policy should best be directed so as to achieve the system-level outcomes – in other words, so as to bring about sustainable reductions in poverty and hunger for the greatest number of people in the shortest period of time. Here recent CGIAR research and discussions on poverty informed the conclusions; specifically ongoing mapping studies on the distribution of populations, poverty and the potential for agricultural growth (see Figure 2.2).

The geographical focus suggested in Scenario 1b could bring sizeable benefits: modeling shows that lifting agricultural production by a further 0.5 percent per year would do substantially more to reduce poverty if that effort were focused on sub-Saharan Africa and South Asia, where poverty is most intense (see the indicative mapping in Figure 2.2 as well as the modelling results in Box 2). However, it should be noted that adding dimensions of poverty other than low income, notably poverty in natural resources such as water and soil, might qualify these conclusions, revealing the need to devote more resources to research in the dry areas of North Africa and Asia (Figure 2.2a).

Figure 2.2. Subnational poverty mapping results, circa 2005

Prevalence (%) circa 2005

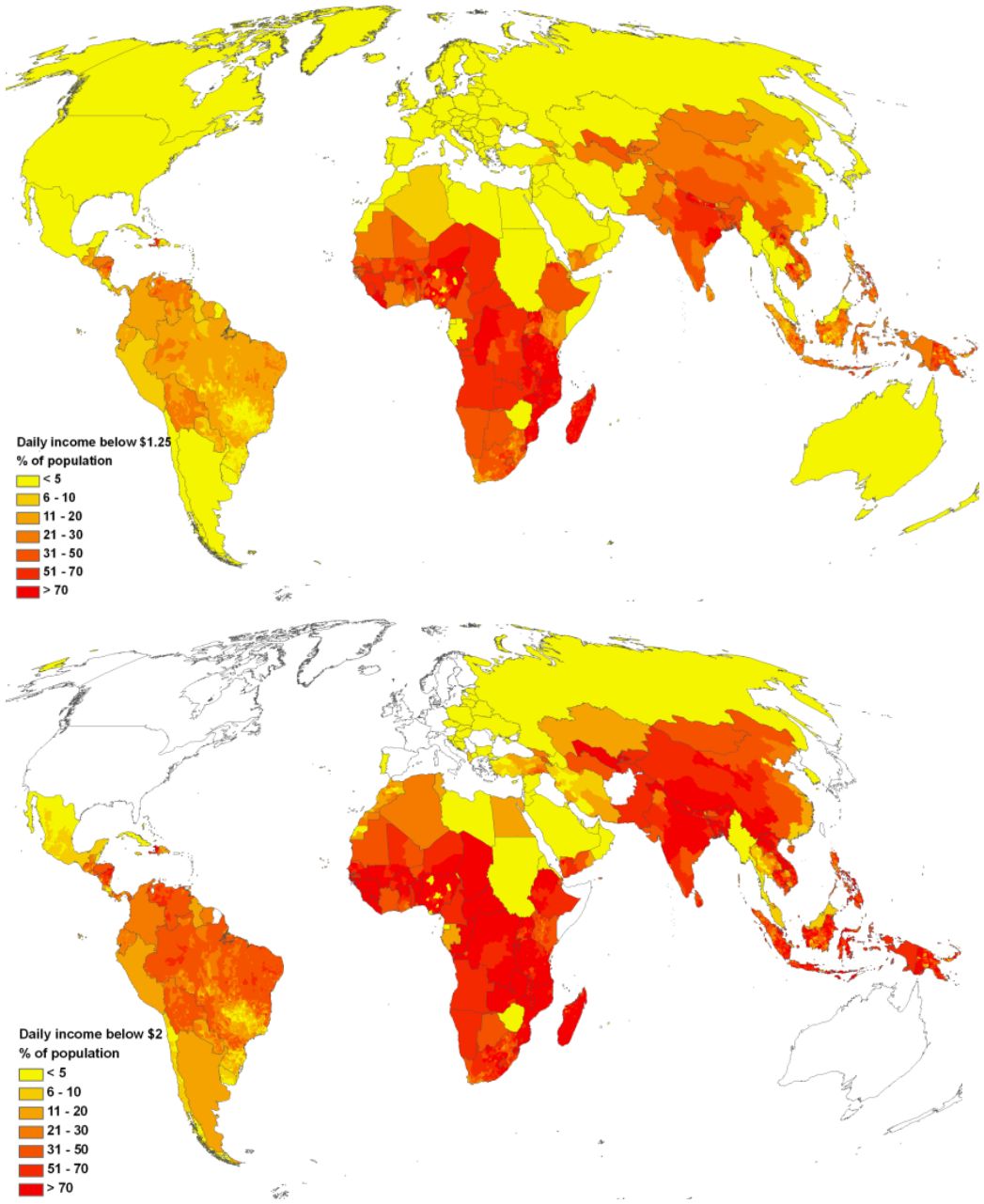
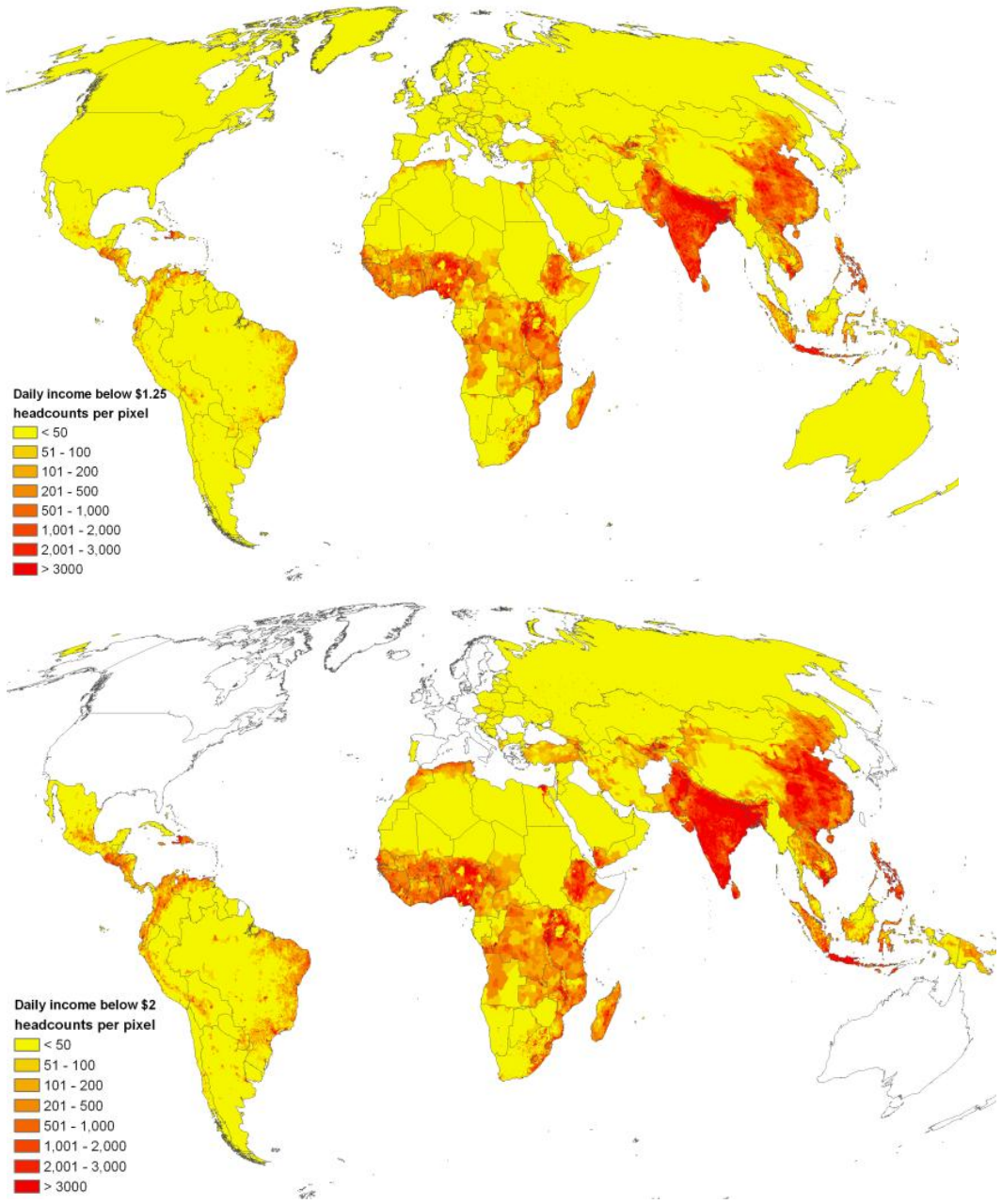


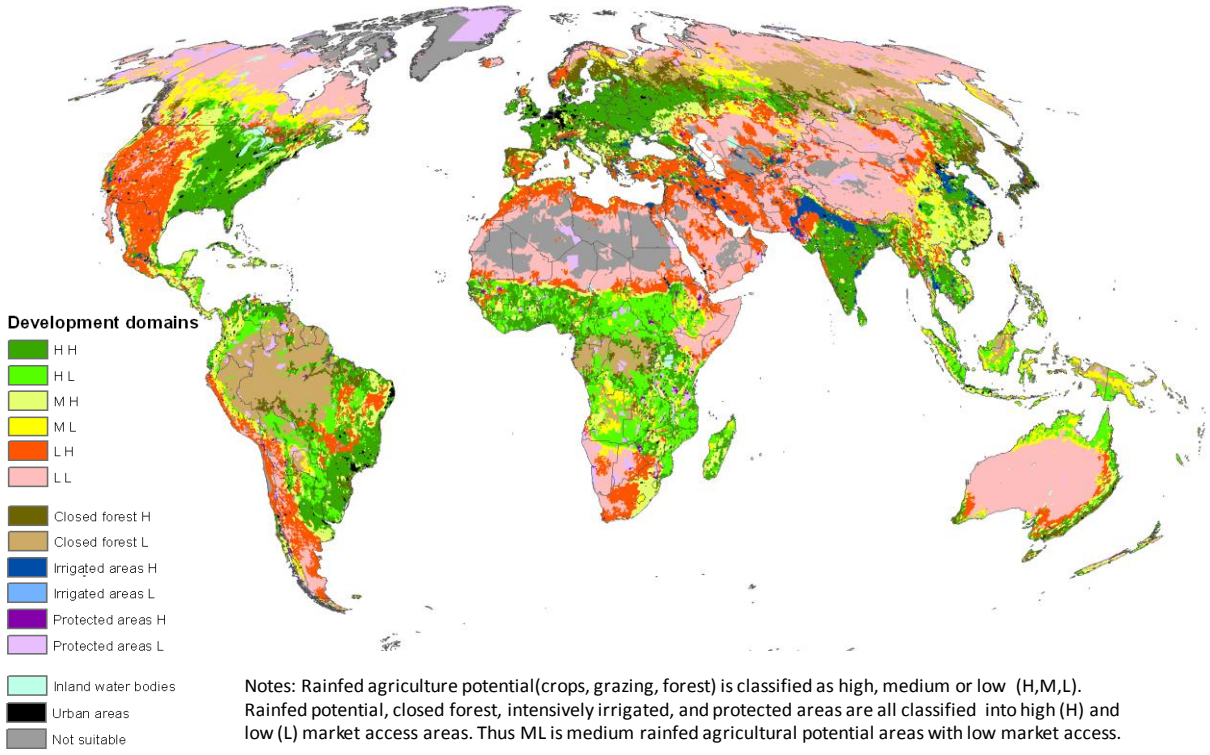
Figure 2.2 (continued)

Absolute number of poor circa 2005



Source: CGIAR Strategy and Results Framework Spatial Analysis Team, Wood et al. (CGIAR, World Bank, RIMISP, and other sources; see background documents on Alliance website).
Note: Units of Figure 2.2 are number of poor people living on < $1.25 and $2/day/grid cell (based on 2005 purchasing-power-parity dollars). These are interim results, and work proceeds to enrich and refine them; results should be interpreted with caution. The spatial resolution of mapping varies widely among countries, as do the specific poverty metrics and thresholds used in individual national results. Where 2005 subnational estimates are based on rescaling of existing national poverty line headcount index (p0) results, the reliability of that rescaling depends on, among other things, the year of the national survey, the change in local consumer prices between 2005 and the survey year, and the gap between the national and the internationally comparable poverty lines (based on 2005 PPP$). The spatial resolution of mapping varies widely among countries, as do the poverty measures and, where relevant, the consumption baskets to which they are applied.

Figure 2.2(a). Development domains: Agricultural potential and market access



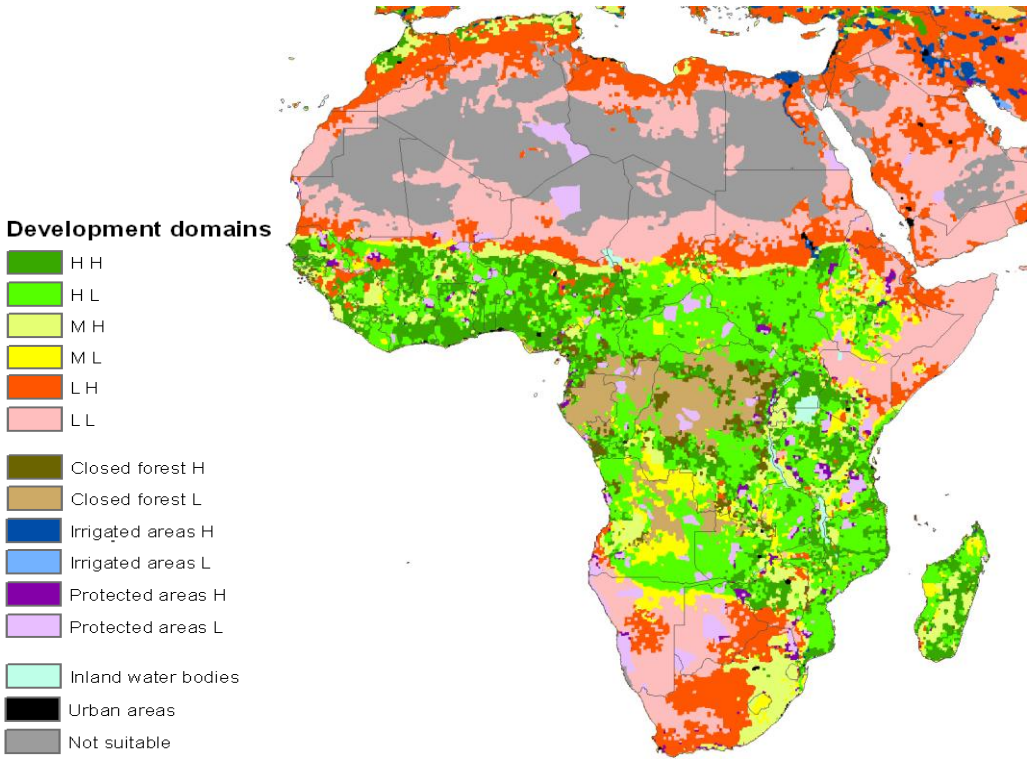
Source: CGIAR Strategy and Results Framework Spatial Analysis Team, Wood et al. (CGIAR, World Bank, RIMISP, and other sources; see background documents on Alliance Web site).
Note: Development domains reflect agricultural potential and market access. Closed forest, intensively irrigated, protected, urban, and not suitable areas are not altered from an agricultural potential map. Other areas of rainfed agricultural potential are classified according to high, medium and low agricultural potential and high or low market access.
LL = low agricultural potential and low market access.; ML = medium agricultural potential and low market access; MH = medium agricultural potential and high market access; LH = low agricultural potential and high market access; HH = high agricultural potential and high market access; HL = high agricultural potential and low market access.

Commodities produced and consumed by the poor

In terms of the amounts produced and consumed, the world food system is dominated by a relatively small set of commodities.[15] As Table 2.3 shows, rice, wheat and maize account for more than 30 percent of calories in dozens of countries whose populations together total more than 4.5 billion people.

[15]. The main three global foods in terms of calorie consumption – rice, wheat and maize – are dominant by a large margin: average daily calorie consumption in developing countries is as follows: rice, 655; wheat, 458; maize, 167; cassava, 55; potatoes, 42; millet, 42; sorghum, 41; sweet potatoes, 35; and pulses, 34 (see FAOSTAT database).

Figure 2.2(b). Development domains (provisional): Agricultural potential and market access in Africa



Source: CGIAR Strategy and Results Framework Spatial Analysis Team, Wood et al. (CGIAR, World Bank, RIMISP and other sources; see background documents on Alliance website).
Note: Development domains reflect agricultural potential and market access. Closed forest, intensively irrigated, protected, urban, and not suitable areas are not altered from an agricultural potential map. Other areas of rainfed agriculture potential are classified according to high, medium, and low agricultural potential and high or low market access.
LL = low agricultural potential and low market access; ML = medium agricultural potential and low market access; MH = medium agricultural potential and high market access; LH = low agricultural potential and high market access; HH = high agricultural potential and high market access; HL = high agricultural potential and low market access.

While these three cereal crops are clearly important at the global scale it is also true that the rural poor depend on a far broader array of crops for their subsistence and livelihoods. These include sorghum, millets, pulses and legumes, plantains and bananas, roots and tubers and range of other locally important species, all of which provide valuable contributions to nutrition as well as to food security, especially when times are hard. Pulses and food legumes are referred to as ―poor‘s man meat" since they are a particularly important source of dietary protein for the poor. Pulses combined with cereals, particularly wheat and rice, provide a fully balanced diet in South Asia, the Horn of Africa and West Asia.

In a number of countries other crops account for more calories than do these three main cereals (Table 3.1, in Chapter 3, illustrates this). The population of these countries adds up to approximately 370 million people; they are among some of the poorest countries in the world with the highest rates of child malnutrition (see Figure 3.6 later in this document).

Furthermore, there is evidence that, in the wake of the recent food price crisis, countries are increasingly adjusting their national food security objectives. Some governments are reconsidering their dependence on imported grains such as rice and wheat in favor of promoting locally-produced food staples.

Table 2.3. The roles of rice, wheat and maize in developing countries' food crop consumption

Commodity	Number of countries where more than 30% of food calories come from these crops, 2003	Population of the countries (millions), 2006
Rice only	18	802
Maize only	10	248
Wheat only	17	564
Rice, maize, and wheat	94	4,574

Sources: Data from FAO (Food and Agriculture Organization of the United Nations), FAOSTAT database (Rome, 2009) and World Bank, *World Development Indicators 2008* (Washington, DC, 2008).
Note: FAO classification for developing countries used for the analysis.

The role of diversity

Achieving the system-level outcomes requires a number of problems, not fully analysed in this document, to be reflected in the thematic research areas. Just as a good diet is not just about quantity but also about nutritive quality, so productive agriculture is not just about yield per hectare but also about the health and sustainability of soil and water resources, biodiversity and of nutrient cycles. Also critical is the ability of all commodities and systems to adapt to climate change. Diversity is fundamental on all these fronts, contributing not only to ecosystem resilience but also to food security, adequate nutrition and the economic stability of smallholder enterprises. The interactions between agriculture and the environment are also crucial since practices that deliver yield gains in the short term may undermine the resources on which future productivity depends. Investing in activities that replenish natural capital is thus key to sustaining and increasing the return on investments in agricultural research.

Ecosystem services and dietary diversity are both supported by diversity in species, not only of crops but also of livestock, fish and trees. Investing in research on these species, and especially on the synergies among them at the system or farm level, will be vital to the success of the CGIAR's strategy. Livestock can represent a ladder out of poverty for millions of smallholders, agropastoralists and pastoralists, who can respond to rising demand for livestock products by diversifying and intensifying their enterprises (see Box 2). Fish are important to diets and livelihoods in coastal areas and also, increasingly, in inland mixed smallholder systems. Planting trees in agricultural landscapes not only generates income in the form of timber and non-timber products (especially fruit), but also performs valuable ecosystem services, such as aiding soil fertility and reducing erosion.

Box 2. Livestock for pro-poor development

The volume of livestock production in developing countries has increased steadily since the early 1980s, both for domestic consumption and for export. Demand is projected to continue to increase rapidly between now and 2050 (Table 2.4). The increase is driven by rising incomes and urban lifestyles, which induce a switch away from traditional cereals to a more diverse diet.

In value terms, milk is the world's most important agricultural commodity – greater in value even than rice. In the least developed countries on which CGIAR research will focus, two of the top three commodities in value terms are livestock commodities. In sub-Saharan Africa, meat is the most valuable agricultural commodity.

Expanding markets for livestock products thus represents a significant income-earning opportunity for small-scale producers. The opportunities are greatest around large cities, which draw in feed supplies, live animals and products such as meat, milk and eggs from an ever-expanding radius. In sub-Saharan Africa, the expansion of peri-urban small-scale dairy production over the past 30 years is one of the continent's major success stories, with a strong impact on pro-poor development as both consumers and producers benefit. Besides producers, the livestock sector creates jobs for processors, traders, truckers, vets and animal health workers, slaughterers, packers and retailers of both inputs and outputs.

The sector is thus a powerful contributor to the CGIAR‘s first strategic objective, to lift productivity and reduce poverty.

Table 2.4. Projections of demand for livestock products in the developed and the developing world

		Annual per capita consumption		Total consumption	
	Year	Meat (kg)	Milk (kg)	Meat (Mt)	Milk (Mt)
Developing	2002	28	44	137	222
	2050	44	78	326	585
Developed	2002	78	202	102	265
	2050	94	216	126	295

Sources: Thornton and Herrero, 2009; Rosegrant et al., 2009.

Diversity can thus make an important difference to the livelihood strategies of small-scale farmers and the rural poor throughout the world. It can insure against crop failure, help with pest control, boost dietary intake, provide a buffer against commodity price changes, create new jobs and income streams, and maintain soil and ecosystem health. Promoting and supporting opportunities for diversification should therefore be a key component of the CGIAR‘s agenda.

Agriculture as a business

The equitable growth of agriculture will depend critically on whether it is perceived and supported as a small business. This is particularly important in poor regions where farm size is shrinking, as in sub-Saharan Africa. Farmers producing on small plots need to diversify into high-value products that raise their purchasing power rather than attempt to grow all their staple foods.

If agriculture is a business, then it depends on entrepreneurial capacity and innovation in order to prosper. Many poor people possess this capacity, as evidenced by the rapid adoption of mobile phones and the spread of innovative enterprises based on their use. Encouraging the further development of the capacity to adopt such innovations among the very poor and vulnerable requires support and investment. For example, innovative insurance tools, such as index-based insurance for crop or livestock enterprises, will be needed to support risk-takers. They will need to be bundled with other forms of support, such as the provision of credit, business advice and market intelligence.

Public–private partnerships will be key to unleashing the potential for innovation and for scaling up business models that work. Research can support these partnerships in many ways – by developing new productivity-increasing technologies, by studying policy and institutional barriers, by devising appropriate regulatory frameworks, and by investigating new opportunities and linking the players, up and down the value chain, who can respond to those opportunities.

Encouraging agriculture as a business will be key to meeting the CGIAR's strategic objective of reducing poverty. In creating a favorable climate for entrepreneurship and innovation, the CGIAR will need to link with programs and groups throughout the world already at work on this issue.

Defining the Thematic Areas

With the foregoing observations in mind, and following the modeling exercise and related consultations, the strategy team carried out a final consultation to reach consensus on the main thrusts of the CGIAR's future program.

First, the team identified a number of challenges that must be tackled through research if the system-level outcomes are to be achieved. It then shortlisted those challenges for which the comparative advantage of the CGIAR – specifically its strengths in agricultural productivity, sustainability and policy research – would have the most effective positive impact and which would allow the CGIAR to maximize the benefits of working with a broad range of partners so as to achieve impact on a large scale.

The challenges identified are to:

- Increase the productivity of staple foods for the poor
- Create the policy environment and market mechanisms needed to improve access to food and raise incomes among poor people, including by supporting smaller agribusinesses and livelihoods
- Address the issues of nutrition and health that are linked with agriculture
- Ensure the sustainable use of natural resources such as soils, water and biodiversity
- Ensure the sustainable management of forestry and agroforestry systems
- Tackle the impacts of climate change and its interactions with agriculture
- Integrate all knowledge and concentrate its application in areas with a high density of poor people.

This list formed the basis for our subsequent identification of seven Thematic Areas. Table 2.5 provides an overview of the Thematic Areas, together with the way in which each contributes to one or more of the system-level outcomes and captitalizes on the CGIAR's comparative advantages, while Table 2.6 summarizes the rationale behind each Thematic Area, the relevant geographical or market

contexts and the cross-links to other Thematic Areas. Section 3 provides a more detailed description of each Thematic Area, together with the proposed MPs to which it gives rise.

Identifying the Thematic Areas entailed a thorough, iterative process, in which we took account of feedback from various stakeholders using surveys, analysis, dialogue and shortlisting tools. References to the methods used and to further source materials are provided in Appendix 1.

Table 2.5. The Thematic Areas: how they fulfil system-level outcomes and reflect the CGIAR's comparative advantages

Thematic Area	System-level (SRF) outcomes met*	CGIAR's comparative advantage
Integrated Agricultural Systems for the Poor and Vulnerable – Research into resilient, diversified and more productive combinations of mixed crop/livestock, rangeland, aquatic and agroforestry systems, with three particular areas of focus: tropical and subtropical drylands; smallholder systems in subhumid, humid and highland areas; and coastal and aquatic ecosystems. Also: addressing issues raised by intervention packages, bearing in mind the benefits of managing systems for diversity and resilience, in addition to managing them for income growth	F, E, P	• Prototypes of center/national partnerships with high payoffs • Ability to convene research on systems that cut across national boundaries • Experience in systems approaches
Policies, Institutions and Markets to Strengthen Assets and Agricultural Incomes for the Poor – Research into institutional, policy and investment changes needed to enhance agricultural income opportunities for farmers, pastoralists and fisherfolk, with a focus on agricultural value chains; policies and investments that enable pro-poor growth; and institutions and governance for the poor.	F, P	• Considerable capacity with potential for strong international integration • Honest broker and partner for evaluating innovations • Strong international public good (IPG)
Sustainable Production Systems for Ensuring Food Security – Research to develop sustainable and resilient productivity increases at the global and regional level as climates change and demands increase, including by accelerating the development and uptake of new varieties; conserving, characterizing and utilizing the world's collections of germplasm for targeting gene discovery; improving crop management and providing information and policy support for pro-poor and gender-sensitive impacts. Will focus on seven main types of crop or food source: rice; wheat; maize; grain legumes; roots, tubers, bananas and plantains; dryland cereals; livestock and fish. A scoping study will determine how to handle cross-cutting research relating to the conservation and characterization of genetic resources.	F, E, P	• Heartland of CGIAR with strong track record; strong IPG • Custodian of genetic resources under International Treaty • Global leadership in genetic resources information systems and policy • Strong and effective networks with NARS and experience with public–private partnerships for crop improvement
Agriculture for Nutrition and Health – Promote, coordinate and undertake cutting-edge research into the interactions between agriculture, nutrition and health, with the aim of reducing poverty and gender inequality, and improving the food, health and nutrition security and dietary diversification of poor populations, through enhanced policy and program effectiveness. Includes research on nutrition-sensitive agriculture; biofortification; new approaches to control of neglected and zoonotic diseases; mitigating health risks in intensifying agri-food systems; and improving agricultural development planning and policy making to achieve better health and nutrition, sustainable intensification of agrifood systems and support to marginal and vulnerable people.	F, P	• Recognized leadership in food and nutritional policy research • Recognized leadership in emerging and zoonotic infectious diseases that impact on both human and animal health • Broad CGIAR capacity in agriculture-health links with good precedents for linking across Centers / NARS and with international health community • Strong IPG
Durable Solutions to Water Scarcity and Land and Ecosystem Degradation – Research the complex interactions between soil, water, ecosystems and productivity; the implications of these interactions for livelihoods; and the role of policies and institutions, as well as farm-level practices, in bringing about improvements.	F, E, P	• Recognized leader and partner in water for food and agriculture; strong IPG • Ability to convene research on water systems that cut across national boundaries

The aim is harmonization of agricultural productivity and environmental sustainability goals to improve water, soil, biodiversity and ecosystems management and to increase water and land productivity for crops, livestock, fish and agroforestry.		• Expertise in tropical soils and agricultural biodiversity
Forests and Trees – Research the technical, institutional and policy changes needed to address the growing risks (including loss of rural livelihoods) from imbalanced land-use change, deforestation, loss of tree diversity, and the resulting degraded ecosystem services. Help conserve, develop and sustainably use agroforestry and forests for humanity; harness forest ecosystem services, including forest, tree and biomass production for sustainable development and the poor; and increase biodiversity and carbon sequestration through avoided deforestation and increased tree-planting.	E, P	• Recognized leader and partner in research on deforestation and agriculture-forestry links • Expertise in forest and tree genetic resources • Strong IPG
Climate Change, Agriculture and Food Security – Coordinated action to diagnose and analyze the directions and potential impacts of climate change for agriculture; to ensure the inclusion of the agriculture, livestock, forestry and fisheries sectors in climate change policies in ways that benefit the rural poor; and to identify and develop pro-poor adaptation and mitigation practices, technologies, and policies for food production systems and rural livelihoods.	F, E, P	• Capacity to link and integrate research on agriculture and climate change • Strong IPG • Existing relevant work in many centers

***(F = Food Security; E = Environmental Sustainability; P = Poverty Reduction)**

Table 2.6 The Thematic Areas: how they will have optimum impact on hunger and poverty

Thematic Area	Major rationale for Thematic Area	Additional information sources	Links to other Thematic Areas and programs
1 Integrated Agricultural Systems for the Poor and Vulnerable	• Spatial concentrations of poor people in specific agro-ecological systems • Need for integrative approaches across technologies, institutions, natural resources, and policies to solve complex problems • Opportunity to show rapid impacts by harnessing the best from the CGIAR system	• IMPACT • Spatial mapping of poverty and agricultural systems, plus their dynamics over time • Washington workshop for the SRF • Mapping diversity of genetic resources for food and agriculture	• Potential links with Thematic Areas 2, 3, 4, 5, 6 and 7.
2 Policies, Institutions and Markets to Strengthen Assets and Agricultural Incomes for the Poor	• Potential of using smallholder agriculture for promoting development and poverty reduction currently under-exploited; needs effective policy environment • Access to information and communications techologies becoming universal, opening huge opportunities for poor people • Critical role of improved markets for inclusion of the poor • Need to manage more frequent shocks from climate change, energy, and so on	• IMPACT • Science Forum • Scientists' Survey • CGIAR Poverty workshop	• Will work with Thematic Areas 1, 3, 5, 6 and 7
3 Sustainable Production Systems for	• Crop, livestock and fish productivity growth critical for food security and poverty reduction	• IMPACT • Science Forum • Scientists' Survey	• Potential links to Thematic Areas 1, 4, 5 and 7

Ensuring Food Security	• Need for CGIAR to develop strong capacity in molecular work to ensure IPGs for pro-poor traits and optimise cross species synergies in molecular biology, genomics and bioinformatics through shared facilites and technologies • Need to recognise and take advantage of the value of wide variety of crops and animal-sourced foods for diversity of both diet and agro-ecological system health and sustainability • Need for learning opportunities across commodities and other crops and food sources • Opportunities for knowledge/technology transfer across species on the conservation and characterization of genetic resources	• Spatial analysis of crops and livestock in relation to poverty • Interface with intergovernmental bodies dealing with genetic resources	
4 Agriculture for Nutrition and Health	• Better access to and utilization of nutritious foods are major determinants of food security • Diet deficiencies of the poor, especially women and young children, require increased attention • Food safety and quality a major transnational concern • Growing linkages between agriculture and health in intensive systems • Emerging and zoonotic infectious diseases a major transnational concern	• Science Forum • Scientists' Survey • Agriculture and health platform of CGIAR • Interest from health researchers in linking with CGIAR	• Potential links to Thematic Areas 1, 3, 5 and 7 • Agriculture and health platform of CGIAR
5 Durable Solutions to Water Scarcity and Land and Ecosystem Degradation	• The looming water crisis has implications for global food security and livelihoods, further heightened by climate change • Major opportunities for better use of water resources and improving soil health for increased agricultural productivity • Need for upstream soils research to ensure that intensified systems are sustainable, and to intensify large areas with problem soils • Retaining and restoring ecosystem services and conserving biodiversity crucial to sustainability, including of soil fertility	• Spatial mapping of water stress • IMPACT • Scientists' Survey • Science Forum	• Potential links with Thematic Areas 4 and 7
6 Forests and Trees	• Deforestation major source of greenhouse gases (GHGs) now recognized in climate change agreements • Livelihoods of about 1 billion poor people • Ecosystem services of global importance (e.g. biodiversity) • Half of all agricultural land has more than 10% of tree cover; represents	• Spatial mapping • Scientists' Survey	• Clear link to Thematic Area 7 through REDD, etc.

	real opportunity with improved germplasm and management		
7 Climate Change, Agriculture and Food Security	• Major threat to poverty and hunger reduction, and sustainability • Agriculture major source of GHGs and has potential to be part of the global climate change mitigation solution; livestock responsible for 18% of GHGs globally • Opportunities from raised CGIAR profile in global climate change agenda and scientific community	• Survey and other consultations • IMPACT model on climate change effects	• Must link with and develop collaborations with all other Thematic Areas, all Centers and the core CCAFS research agenda

The descriptions of the Thematic Areas, and the brief outline of the proposed MPs delineated within them, take into account the regional consultation process that led up to the first Global Conference on Agricultural Research for Development (GCARD), held in Montpellier in March 2010, the many comments made at GCARD itself, and the guidance of donors and other stakeholders immediately following the conference. Representatives of key partner organizations at GCARD indicated that our proposals broadly corresponded to the priorities identified by stakeholders and were in line with the CGIAR's comparative advantages.

At this stage the MPs are not yet fully defined and therefore cannot be described in detail. The final descriptions will come with the business plans that will be developed for each. However MPs in three Thematic Areas (1, 3 and 7) were identified for fast-track development in the deliberations that followed GCARD. The rest will follow later in 2010.

It is also proposed that a scoping study is undertaken to assess how best to address the cross-cutting aspects of characterizing, conserving and mobilizing agricultural genetic resources in order to best serve the research objectives of all the MPs. Knowledge about genetic resources is key to much of the work set out in the SRF and an important area in which the CGIAR already plays an important role in providing International Public Goods.

Ultimately, the new Thematic Area/MP structure will enable the reformed CGIAR to feature:

- Clearer partnerships with more explicit development impacts
- Better articulation of the CGIAR's role compared with that of other stakeholders
- Emphasis on agenda-setting for complex issues
- Emphasis on strengthening partners' capacity to innovate
- Development of cutting-edge approaches and methods
- More effective knowledge management and sharing
- Better targeting of research investments to maximize impact.

3. Thematic Areas and Cross-Cutting Capacity

Characteristics of the Thematic Areas

The keystones of the SRF are the seven interlinked Thematic Areas. Each Thematic Area caters to the system-level results and has its own set of indicators that are broadly consistent with the overall SRF (see Figure 3.1).

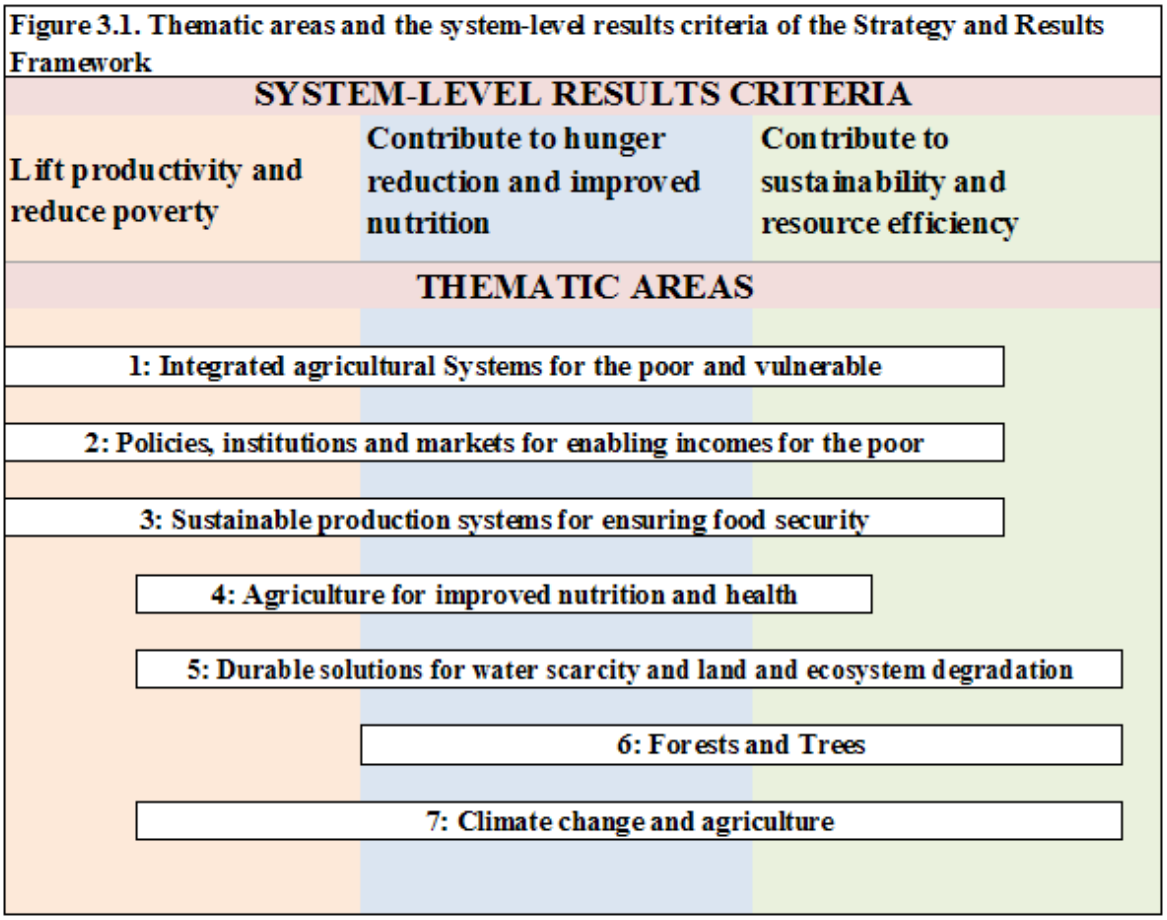


Figure 3.1. Thematic areas and the system-level results criteria of the Strategy and Results Framework

The Thematic Areas will be underpinned by three proposed areas of cross-cutting functionality, intended to provide systemwide support in the areas of gender, capacity strengthening and strategic planning.

This section describes the Thematic Areas, ending in each case with an outline of the MP research areas that are proposed for the purpose of meeting the objectives of that Thematic Area.

The Thematic Areas have been developed with a number of criteria in mind. Each Thematic Area:

- Addresses one or more of the three strategic objectives and takes advantage of the opportunities available to achieve results and impacts over time
- Is of sufficient scope and scale to deliver high-level development outcomes and/or measurable development impacts
- Reflects the CGIAR‘s comparative advantage in leading or catalyzing research, given the CGIAR‘s assets (physical, biological, human, intellectual, institutional, reputational, collective, etc.)
- Allows for the mobilization of resources, capacity and synergies among program partners, both within and outside the CGIAR, so that the impact will be greater than the sum of the parts
- Has a clear impact pathway that specifies the delivery systems leading to outcomes and impacts
- Is global or regional in focus, with a strong international public goods element

For the CGIAR to achieve its vision of reduced poverty, improved health and nutrition, and enhanced ecosystem resilience, adequate investments must be made in all the MPs that are ultimately agreed for each Thematic Area. The level of these investments will be specified in the business plans for each MP.

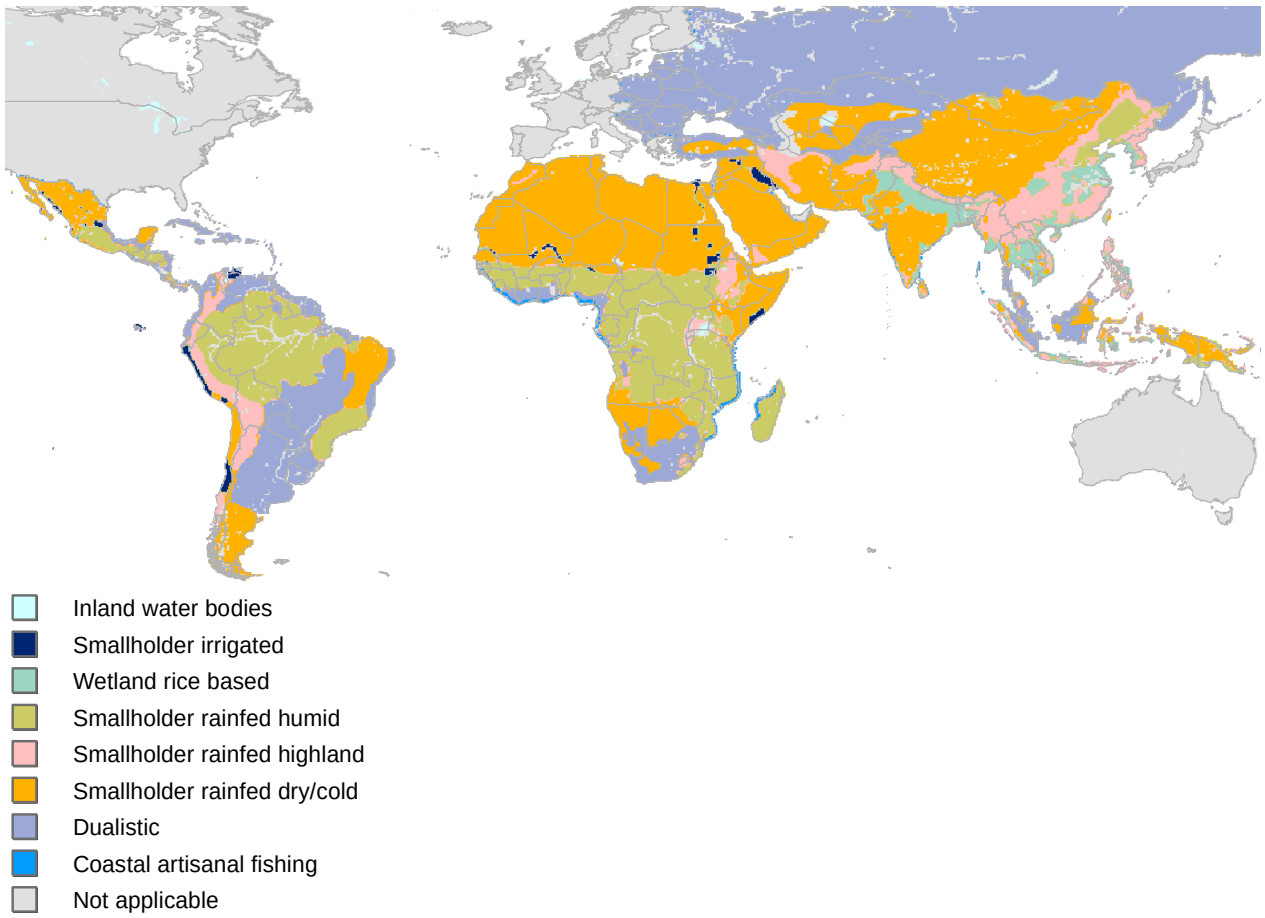
Description of Thematic Areas

Thematic Area 1: Integrated Agricultural Systems for the Poor and Vulnerable

Eight hundred million poor and vulnerable people live in communities that depend on farming, herding, fishing and agroforestry, often in combination, for their food security and livelihoods. Poor and hungry people are concentrated in particular regions and associated with particular agroecosystems, mostly in sub-Saharan Africa and South Asia (Figure 3.2). These systems are characterized by major constraints, such as drought or other agro-climatic challenges, poor infrastructure and underdeveloped markets, or weak institutions and governance. Frequently all three of these major constraints are present simultaneously, interacting to trigger a downward spiral of deepening poverty, hunger and resource

degradation. And the challenges are multiplying, as a result of rising demands for food, competition for land and water resources, and climate change.

Figure 3.2. Dominant agricultural systems



Source: CGIAR Strategy and Results Framework Spatial Analysis Team, Stan Wood et al. (see background documents on Alliance Web site). Data taken from regional maps generated for inclusion in Dixon et al., *Farming Systems and Poverty* (Rome and Washington, DC: FAO and IFPRI, 2001).

The rationale for Thematic Area 1 is to attack poverty and hunger directly, in the areas where they most constrain human development. The aim will be to target opportunities for synergy in mixed agro-ecosystems with high concentrations of poor people, using combinations of enterprises and technologies that draw on the best that the CGIAR and its partners have to offer in order to deliver rapid results that enhance lives and livelihoods. Research under Thematic Area 1 will integrate methods for increasing productivity with management approaches that enhance ecosystem resilience and initiatives to foster more effective links to markets. It will have a strong focus on gender issues, given the differing roles played by men and women in these agro-ecosystems and the need to empower women as decision-makers, entrepreneurs, resource users and farmers.

Research conducted under Thematic Area 1 will contribute to all three of the CGIAR‘s three strategic objectives. It will be directed towards developing international public goods that address several MDGs, notably MDG1 – reducing poverty and hunger. And it will lead to

improved production options, resource management alternatives and policies for poor and hungry people.

Besides the diverse array of key food crops on which poor people depend, research under this Thematic Area will also focus on livestock and fish, wherever these are also important to poor people's diets and incomes.

Specifically, Thematic Area 1 has three objectives that will determine its main areas of activity. The first is to identify and develop resilient, diversified and more productive combinations of mixed crop/livestock, rangeland, aquatic and agroforestry systems that have the potential to be deployed on a wider scale, especially in dry areas where water is scarce (Box 3). The second is to explore similar combinations for the sustainable intensification of smallholder, mixed systems in the subhumid, humid and dryland areas. The third is to research ways of improving the productivity and resilience of coastal and aquatic agro-ecosystems. Links to markets, often across zones, will be important in all three cases.

Box 3: Why focus on the drylands?

Of all the world's agro-ecosystems, the tropical and subtropical drylands face the gravest threats to lives and livelihoods caused by environmental degradation and climate change. Arguably, they also have the greatest potential for sustainable increases in productivity and incomes.

As a percentage of local population levels, poverty is disproportionately concentrated in arid, semi-arid and dry subhumid areas. A study conducted in early 2010 showed that 2.5 billion people live in the dry areas of the developing world, which completely or partially cover some 45 countries in East and South Asia, sub-Saharan Africa, North Africa–West Asia, Central Asia and Latin America. A conservative estimate is that 21 percent of the population in these areas lives on less than US$1 per day and 51 percent on less than US$2 per day. Some 16 percent of children under 5 are undernourished. However, poverty is not merely a matter of low incomes and inadequate food availability: issues such as chronic water scarcity, rising levels of drought and heat, severe soil erosion, loss of forest and biodiversity, and advancing deserts also keep people trapped in poverty; added to these resource constraints are a host of socio-economic problems including complex tenure arrangements, poor access to credit and inputs, remoteness from markets, and the disadvantaged status of women – to name but a few.

Despite this catalogue of problems, advances in research over the past two decades mean that technologies are now available that can make a difference. These include short-cycle varieties of key food staples; drip irrigation and market gardening; the introduction of new fruits and vegetables; breeds of livestock that resist pests and diseases; the precision application of mineral fertilizers; the introduction of *Atriplex* bushes to barley systems – and more. Many of these technologies have been tested over small areas and are now ripe for scaling up.

The pressure on land in the drylands tends to be relatively low and market access remains generally poor, so farmers here have until now had little incentive to raise yields. With the technology to do so now developed but not yet widely extended, it is here that the gap is highest between what farmers are actually achieving and what could be achieved. Their efforts to close that gap must now be supported, not just through international public sector research but also by national research and extension services, NGOs, and the growth of private sector enterprise. Infrastructure development, linking farmers to larger markets in wetter areas, will be vital. So too will be the provision of inputs and services, especially access to credit.

Sources: Verstraete et al., 2009; Chapin et al., 2009.

Four general principles will guide the design of research. First, research will be tightly structured around major system constraints (such as drought risk) and opportunities (such as new markets) rather than around disciplines, commodities or resources. Second, it will aim for quick payoffs through productivity improvements at the system level, with due attention to sustainable use of natural resources and resilience to climate change-related shocks, which are likely to become more frequent. Third, it will employ a value chain perspective that includes agro-enterprises, with a strong emphasis on value added for all products, but especially those (such as livestock) with a strong potential for market growth. Finally, it will be conducted in close partnership with national and subregional research organizations.

Research under this Thematic Area will focus on key mixed agro-ecosystems for which integrated packages of interventions can be developed. Table 3.1 shows how important various crops other than the three main cereals are to people's diets in a number of countries. Table 3.2 shows how a number of mixed agro-ecosystems, especially rainfed systems, are distributed widely across developing regions and are home to many poor people. CGIAR research of an international public goods character is especially relevant for these systems.

Table 3.1. Developing countries where crops other than rice, wheat, and maize dominate food calorie consumption (excluding feed use), 2003

Country	Most important food crop	% in total crop calorie consumption	Population of country (million)
Angola	Cassava	31.4	16.5
Burkina Faso	Sorghum	27.8	14.4
Chad	Sorghum	20.4	10.5
Congo, DR	Cassava	55.6	60.6
Ghana	Cassava	24.4	23.0
Mozambique	Cassava	35.6	21.0
Niger	Millet	49.8	13.7
Nigeria	Sorghum	13.3	144.7
Sudan	Sorghum	29.2	37.7
Uganda	Plantains	17.7	29.8
Total			372.1

Source: Data from FAO 2009.
Note: FAO classification for developing countries was used for the analysis. Countries with population less than 10 million were excluded from the analysis.

In each agro-ecosystem, CGIAR and national researchers will develop a research portfolio based on the most promising crop, livestock, tree and fish combinations, as well as the specific natural resources and market and institutional challenges that must be addressed to improve productivity and raise incomes.[16]

[16]A model for how this can be done through CGIAR–NARS collaboration is the Ric–Wheat Consortium, which, through agricultural innovations such as zero tillage of wheat, generated significant regionwide benefits in a system for poor people. Follow-up research has integrated pulses, livestock, water and gender issues into the program. Other models with emphasis on ecosystem services (such as CONDESAN), agro-enterprises (IITA) and innovation systems approaches (Sub-Saharan Africa Challenge Program) also provide important lessons.

The design of research under this Thematic Area requires a deliberative process to determine the agenda, based on ground-truthing and modeling to identify the most promising agro-ecosystems and enterprise combinations. The agenda will mainly involve developing packages of innovations, adapting these to suit local conditions, and linking agriculture, ecosystem services and policy research.

Given its focus on poor regions where national research systems tend, with a few notable exceptions, to be weak, capacity strengthening will need to play a larger role in this Thematic Area than in others. Moreover, the focus on several systems within this Thematic Area provides an important opportunity for institutional learning across systems. Likewise, this Thematic Area offers good opportunities for South–South collaboration – for example, harnessing Brazilian experience in the *cerrados* to the Guinea savannah regions of Africa[17].

The key partners for research under this Thematic Area, which will mainly target smallholder farmers, will be national and regional agricultural research institutions and NGOs. National systems and subregional organizations will play a strong role in the governance of each MP under this Thematic Area. These MPs will especially benefit from international cooperation with cooperative and producers‘ organizations, which will be important partners in testing innovations.

[17] Stress-adapted multi-purpose forages of the kind developed in the *cerrados* are particularly well suited to smallholder crop–livestock systems located in vulnerable regions. In these systems improved forages are a key component for raising incomes and increasing system resilience.

Table 3.2. Preliminary assessment of the number of people living on less than US$1.25/day ($PPP 2005) in developing regions by development domain, circa 2005 (millions)

	Latin America & Caribbean		Sub-Saharan Africa			Middle East & North Africa		Asia				
Development Domain	*Central*	*South*	*West*	*East & Central*	*Southern*	*M. East*	*N. Africa*	*Central*	*East*	*South*	*S. East*	Total
Rainfed H H	1.2	6.3	*57.1*	*34.3*	12.1	0.0	0.2	0.7	*43.0*	*273.1*	25.9	453.9
Rainfed M H	5.8	5.6	26.8	*32.7*	11.1	0.1	1.1	1.4	*51.1*	*59.1*	23.2	218.0
Rainfed H L	0.2	1.1	14.7	14.1	7.7	0.0	0.0	0.0	5.4	11.3	4.0	58.6
Rainfed L H	0.8	1.7	8.9	3.9	2.2	2.2	1.1	2.7	11.4	21.7	0.7	57.3
Rainfed M L	0.2	0.7	5.1	5.0	1.3	2.6	0.3	1.6	10.5	10.4	1.1	38.8
Rainfed L L	1.1	2.0	8.1	19.5	7.1	0.0	0.1	0.2	26.5	13.0	11.1	88.7
Irrigated areas H	0.1	0.1	0.0	0.0	0.0	0.2	0.8	4.8	13.8	*100.1*	0.3	120.2
Irrigated areas L	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.7	2.7	0.0	3.5
Closed forest H	0.0	1.2	1.1	4.4	0.7	0.0	0.0	0.0	2.6	7.2	0.1	17.5
Closed forest L	0.0	1.8	1.7	9.4	2.5	0.0	0.0	0.0	4.5	5.3	1.7	27.0
Protected areas H	0.2	0.6	0.7	1.9	0.3	0.0	0.0	0.2	1.0	8.6	0.5	14.1
Protected areas L	0.1	0.7	1.2	3.5	0.7	0.0	0.0	0.1	0.3	2.8	0.9	10.3
Not suitable	0.0	0.1	0.3	0.1	0.0	0.1	0.2	1.2	1.5	0.8	0.0	4.3
Grand Total	**9.8**	**22.1**	**125.8**	**128.7**	**45.7**	**5.1**	**3.9**	**13.1**	**172.3**	**516.2**	**69.4**	**1,112.1**

Source: CGIAR Strategy and Results Framework Spatial Analysis Team, Wood et al. (see background documents on Alliance website).
Note: Rainfed agriculture potential (crops, grazing, forest) is classified as high, medium or low (H,M,L). Rainfed potential, closed forest, intensively irrigated, and protected areas are all classified into high (H) and low (L) market access areas. Thus ML is medium rainfed agricultural potential areas with low market access. Also see map of development domains (Figure 2.2a-b). Inland water and major urban areas were omitted from this tabulation, so absolute poverty numbers are less than in the Agricultural Systems MP summary (areas and populations to be reconciled in revised versions). Regional domains with greater than 30 million poor people are highlighted (red italics).

It is estimated that research under this Thematic Area could reach 250 million poor people over 10 years, achieving broad based productivity increases of at least 10 percent and lifting about 60 million people out of poverty (defined as an income of less than US$1.25 per day).[18]

It is proposed that this TA will subdivide into three components for management purposes, focusing respectively on:

- Integrated agricultural production for dry area systems
- Integrated systems for the humid tropics
- Harnessing the development potential of coastal and aquatic agricultural systems.

[18] This calculation is based on an average of 50 million poor people in each of five systems, an increase in productivity growth of 1 percentage point a year, and a poverty-output elasticity of 2.5 percent in poor regions.

Thematic Area 2: Policies, institutions and markets for strengthen assets and agricultural incomes for the poor

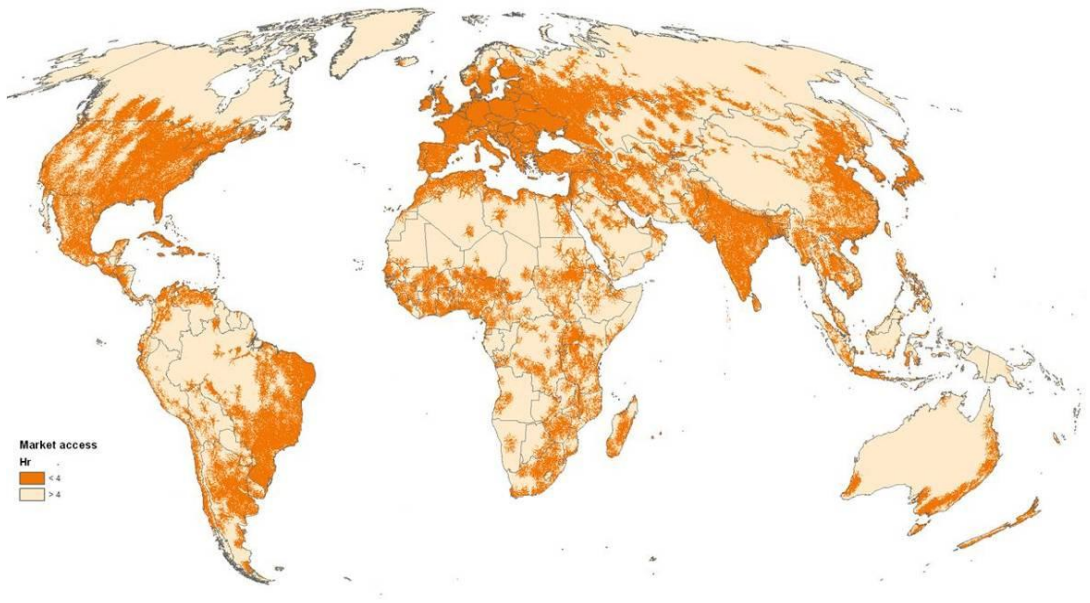
Agricultural growth reduces poverty at a rate that is at least twice that of non-agricultural growth, yet the potential of smallholder agriculture to promote pro-poor development remains underexploited. Improving the policy and institutional environments in which poor producers, processors, traders and other small-scale entrepreneurs operate represents an underutilized opportunity for reducing poverty and improving food security.

Macro-economic policy reforms, trade and agricultural sector policies, investments in rural infrastructure, institutions that strengthen markets, and more effective governance can play a critical role in enabling incomes for the poor. Policy and institutional innovations are therefore as important as technological innovations for achieving the CGIAR's goals.[19] In recent decades, important institutional innovations have included the worldwide microfinance revolution and collective arrangements for managing communal resources such as water and forests. At the same time, there were – and still are – many policy and institutional failures and aberrations, such as government-commandeered agriculture and ill-designed resettlement schemes. Such failures often have particularly severe implications for women.

Whereas most Thematic Areas include some policy and institutional research to support their outcomes and impact pathways, this Thematic Area focuses directly on innovations in these areas, as a complement to the technological focus of much existing CGIAR research. Activities under this Thematic Area will aim to unleash an ~~"~~institutional and information revolution" with and for farmers and the rural poor – a revolution that not only improves and secures livelihoods but also promotes innovation along value chains. Areas of low market access, as shown in Figure 3.3, have particular difficulty in entering new agricultural value chains and thus are in great need of policy and institutional innovations to make their agricultural products competitive and to reduce their vulnerability to shocks.

[19]. The 2009 Nobel Prize for economics was awarded to two institutional economists, Elinor Ostrom and Oliver Williamson, highlighting the recent innovations in and importance of research on institutional arrangements for development.

Figure 3.3. Areas of high and low market access



Source: Adapted from Nelson 2008.
Note: Locations within 0–4 hours' travel time from a market are classified as having high market access. Locations more than 4 hours from a market are classified as having low market access. This classification reflects a simple rule of thumb: in areas with high market access, it is feasible to travel to and from the market and make transactions in one day.

Research under Thematic Area 2 will focus on three interlinked components: agricultural value chains; policies and investments that enable pro-poor growth; and institutions and governance for the poor. It will aim to make the CGIAR a global leader in institutional innovations for agricultural development and to facilitate learning on these across systems and regions. It will also address the core policy challenges that have often prevented the effective use of agriculture for development. And it will cover a range of innovations and interventions to improve the performance of financial, input and output markets, and to reduce the effects of market and climatic risks for poor producers.

Global in its reach, this Thematic Area has the overall goal of creating a policy and institutional environment conducive for agriculture that contributes fully to poverty reduction, sustainable rural development and income growth. It will do so by advancing research and impacts on the ground for five major objectives to reach 15 million rural smallholders by 2016 and 75 million rural smallholders by 2030, together with multiplier effects to benefit landless labor and the non-farm rural sector households.

It will also benefit other small-scale entrepreneurs along the value chain. And it will have a strong gender research component. It will work closely with Thematic Area 1, on Integrated Agricultural Systems for the Poor and Vulnerable, and on Thematic Areas 5, 6, and 7, on Water, Forests and Climate Change.

Thematic Area 2 will entail strong cooperation with policy bodies, national and regional research organizations, advanced research institutes, universities and leading professional associations (such as the International Association of Agricultural Economists); with multilateral financial organizations and private firms (such as banks); and with farmer and community-based organizations (including IFAP). Research on innovation systems will require close cooperation with informal policy groups, such as the Neufchatel group, with forums, such as GFAR, and with specialized programs, such as the Research into Use (RIU) program of the UK's Department for International Development (DFID). In a new departure for the CGIAR, this Thematic Area will cooperate closely with private partners who are driving the adoption of information and communications technologies (ICTs) in rural areas, the aim here being to enhance the content of ICT-based services for small-scale producers and the rural poor. It will also make use of new technologies such as digital survey methods and geographical information systems (GIS).

This Thematic Area will form a single proposed MP for management purposes on:

• Policies, institutions, and markets.

Thematic Area 3: Sustainable production systems for ensuring food security

Rice, wheat and maize provide more than 30 percent of the food calories in developing countries inhabited by 4.6 billion people and almost a billion of the world's poorest people depend on income derived from these staples. Unless a new leap forward in yields can be taken, prices of these crops are predicted to increase by 170 to 250% by 2050 due to rising demand and climate change, with serious implications for poor people, especially women and children. Yet yield growth in these staples has been slowing, and production will slip below demand unless R&D investment increases sharply.

As we have seen, at regional and local levels, other crops may be just as important as these three major cereals in providing poor people with subsistence and incomes. Among the other cereals are barley, sorghum and the millets, which are vital for survival in the world's drylands, where conventional maize is too risky. Pulses and legumes are important for feeding livestock and nourishing the soil in addition to diversifying poor people's diets. Among the legumes for direct human consumption, beans have the largest share of world production, with more than 12 million tonnes produced annually. Common bean is a staple in Eastern and Southern Africa and in Latin America, with climbing beans regularly yielding 3 tonnes per hectare or more. The genetic resources of *Phaseolus* span a remarkably wide range of ecological niches, from humid to arid, offering farmers and their families nourishing options over a wide area of the tropics. Bananas and plantains are an important source of income and subsistence in the more humid rainfed regions, while root and tuber crops grow in a range of environments and provide a very diverse array of income-earning opportunities in addition to meeting food needs, often under difficult conditions. Cassava, for example, grows in poor soils and provides a crop when much else fails. It also offers opportunities for small-scale processing enterprises in large areas of Asia, Latin America and West Africa.

Livestock already account for some 40 percent of total agricultural GDP globally and the demand for livestock products is rising rapidly with incomes and urbanization. Livestock are an enterprise with which most small-scale farmers are already familiar, making it easy for

them to invest in expanding or upgrading their holdings. Besides their potential to raise incomes and improve nutrition on the farm, especially among women and children, livestock have important integrative functions in the farming system, often providing the economic rationale for planting resource-conserving trees, shrubs and leguminous crops, contributing to soil fertility and/or local fuel supplies through their manure, and, in the case of cattle, camels, donkeys and horses, aiding in ploughing and other operations, such as threshing, weeding or transport. Worldwide, some 3.4 billion hectares of grazing land plus a quarter of the crop area are used to feed livestock. Multi-purpose tropical forages are thus a prominent feature of crop–livestock systems around the world and in some areas represent the largest form of agricultural land use. Forages also rank among the highest value crops in many countries and contribute to the sustainable intensification of crop–livestock systems. As the livestock sector grows in the coming years, a key constraint holding smallholders back will be the spread of animal diseases. These will have to be closely monitored and investments made in tackling them, through the development of vaccines and other solutions.

Protein from fish is an essential element of the diet in coastal communities and is increasingly important inland as well. A traditional element of irrigated rice paddies, fish of several different species are now enabling small-scale farmers, even in rainfed systems, to diversify their traditional crop–livestock systems. Fish must increasingly be raised in such systems if conventional fisheries, in oceans and rivers, are not to be exhausted.

The world‘s farmers need to produce 40–50 percent more staple foods by 2030 to meet the strongly growing demand for food, feed and fuel from an increasing world population with rising incomes. Furthermore, farmers need to increase production in a changing climate and using about the same land area and less water than they do now; otherwise, agriculture will encroach still further into forests and marginal drylands and water scarcity will increase. If yields do not increase sharply, food prices will rise, with serious consequences including increased levels of hunger, poverty – and conflict.

This presents an unprecedented challenge to the R&D community. To meet it will require an integrated approach that links world-class science with farm-level innovation. It will also need the engagement of both public and private players in an effective global alliance that sustainably increases the productivity of all crop and animal production systems.

Figure 3.5 shows the areas suitable for growing crops worldwide. Productivity increases will depend on genetic gains; more efficient and sustainable use of water, nutrients and land; and improved host plant resistance to pests and diseases, including newly emerging ones. The CGIAR has documented large-scale successes in sustaining and improving the availability of food and reducing poverty through crop productivity enhancement. While the private sector is increasing its investment in the food crops of the developing world, the CGIAR maintains a strong comparative advantage in delivering international public goods to the benefit of farmers.

The inclusion within this Thematic Area of the three major cereal crops will be highly relevant for food prices in developing countries and important for preventing widespread starvation and social unrest. The focus on other commodities will also be important for preventing hunger and poverty in less favoured environments and regions – and for diversifying diets and incomes as well as sustaining ecosystems. Thematic Area 3 will result in sustainable and resilient productivity increases at the global, regional and local levels as climates change and

demand rises. These increases will ensure higher incomes for small-scale producers, affordable food for poor people, especially women and children; and reduced requirements for more land, water, nutrients and fuel, thereby preserving natural ecosystems.

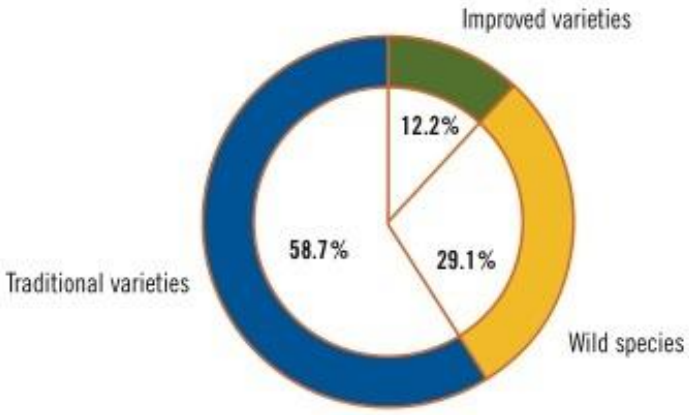
For both the major cereals and the other crops and commodities, continued access to and conserving and characterizing the genetic resources that must underpin further yield increases is vital. This work will seek to increase the effectiveness and efficiency of both *ex situ* and *in situ* conservation; to develop and apply new tools for the conservation, characterization and documentation of genetic resources; to develop informatics tools that will increase ease of access to information about genetic resources; and to create an enabling policy environment for the conservation and use of genetic resources, including access to all bona fide users. This work will draw on the large collections of genetic resources already held by the CGIAR Centers, which are particularly strong in the traditional varieties and crop wild relatives that are the most useful sources of traits for breeders (Table 3.3 and Figure 3.4). In pursuing this work the CGIAR will collaborate closely with relevant global processes and arenas, including the FAO Commission on Genetic Resources, the Convention on Biological Diversity, the International Treaty on Plant Genetic Resources for Food and Agriculture, the Intergovernmental Committee on Intellectual Property and Genetic Resources, Traditional Knowledge and Folklore – and others.

Table 3.3. CGIAR genebanks contain more than 655,000 accessions of plant diversity, held in trust under international agreements. Collectively, the CGIAR genebanks represent the world's largest collection of agricultural biodiversity.

CENTER	SCOPE OF COLLECTIONS	NUMBER OF SAMPLES held in trust
Africa Rice	Rice	21,527
Bioversity	Banana and plantain	989
CIAT	Beans, cassava, forages	65,290
CIMMYT	Maize, rye, triticale, wheat	168,103
CIP	Andean roots and tubers, potato, sweetpotato	13,623
ICARDA	Barley, chickpea, faba bean, forage, lentil, wheat	125,506
ICRAF	Agroforestry trees (>200 species)	>10,000
ICRISAT	Chickpea, groundnut, pearl millet and other millets, pigeonpea, sorghum	113,830
IITA	Bambara groundnut, cassava, cowpea, soybean, yam	25,402
ILRI	Forages	18,661
IRRI	Rice	102,652
TOTAL		665, 608

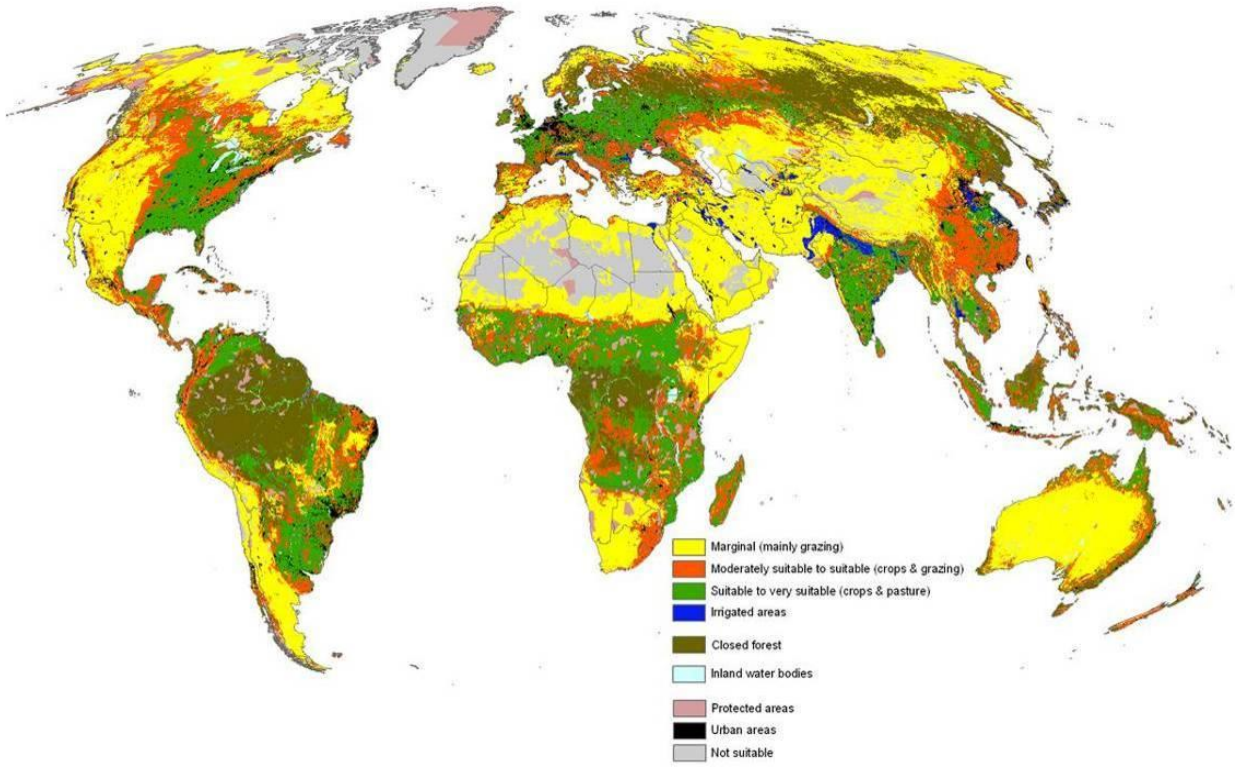
Adapted from: Safeguarding the World's Agricultural Legacy, CGIAR, 2008.

Figure 3.4. The CGIAR's genebank collections are especially rich in the wild relatives and traditional varieties that are most likely to supply the traits needed to meet the challenges of increasing production and resilience.



Source: As for Table 3.5

Figure 3.5. Crop potential



Source: Adapted from FGGD (FAO 2007).

Note: This figure shows the potential for rainfed production of pasture, crops and trees, with existing irrigated areas, closed forests and inland water bodies.

The main objectives of Thematic Area 3 are thus to:

- Ensure access to, conserve, characterize and utilize the world‘s collections of crop, livestock, fish and microbial germplasm for targeted gene discovery
- Accelerate the development and dissemination of more productive and resilient crop varieties and their adoption by farmers in the major farming systems of Africa, Asia and Latin America
- Accelerate the development and dissemination of more productive and resilient livestock and fish strains and breeds and their adoption by producers in the major production systems of Africa, Asia and Latin America
- Develop more efficient and sustainable management options for all the world's major food commodities, better post-harvest technologies to prevent wastage, and new options for adding value and linking to value chains
- Propose policy and institutional innovations and provide information that will ensure pro-poor income growth and gender-sensitive impacts.

Thematic Area 3 will particularly impact food security and poverty reduction in the poorest regions and among most food-insecure people. In total, research under Thematic Area 3 is expected to benefit a minimum of 3 billion people. Other expected results of work under this Thematic Area include the CGIAR becoming a recognized leader in applied genomics, enabling it to partner effectively with agricultural research institutions and the private sector to identify and transfer pro-poor crop, livestock and fish traits; eco-efficient cultivars and strains that require fewer inputs of water, fertilizers, pesticides and labor, and produce higher yields while having a positive impact on the environment; and easy access for farmers to those improved cultivars and strains.

Thematic Area 3 will provide truly global, efficiently managed R&D platforms for the world‘s major food, feed and fuel commodities, in which the activities of CGIAR Centers are fully aligned with those of all other strategic partners in the public and private sector. Research plans will be developed collaboratively, building on existing networks of partners, subregion by subregion, and previously fragmented activities will be properly integrated. There will be a particular emphasis on strengthening links with advanced research institutes and national research partners, while new partnerships will be developed with the private sector worldwide, and partnerships with NGOs at the grassroots level will be expanded. Co-investment and guidance from Thematic Area 4, Thematic Area 5 and Thematic Area 7 will create further impacts on nutrition, health, ecosystem services and adaptation to climate change, respectively.

To conduct research under Thematic Area 3, the CGIAR will deploy its strong comparative advantages in allele and trait mining, applied genomics, bioinformatics, precision phenotyping, strategic genetic enhancement, targeting and forecasting, innovative crop and resource management R&D, capacity building, and the provision of information. It can also harness and adapt research products and approaches from advanced research institutes and

bioscience companies to the benefit of the poor. The CGIAR has already shown itself to be highly effective in facilitating and building the capacity for participatory, impact-oriented research in crop, livestock and fish systems and in value chain and policy research among countries confronting similar challenges. It has also promoted effective links with the multinational and local private sector and builds on a strong tradition of collaboration with partners on cross-cutting issues relating to genetic resources research.

It is proposed that, for management purposes, this Thematic Area will subdivide into 7 commodity-specific component MPs as follows:

- Rice-based systems
- Wheat-based systems
- Maize-based systems
- Grain legumes
- Roots, tubers and bananas
- Dryland cereals
- Livestock and fish

In addition, a scoping study is needed to establish how best to address the issues relating to cross-cutting research on genetic resources for food and agriculture so that the requirements in this area for the commodity-specific MPs are fully supported.

Thematic Area 4: Agriculture for Improved Nutrition and Health

The explicit inclusion of a Thematic Area on health and nutrition and their links with agriculture is one of the novel elements of the SRF.

Agriculture is the primary source of livelihood and nutrients for the majority of the world‘s poor, who in turn are also most vulnerable to malnutrition and ill-health. Agriculture supports nutrition and health by providing food, energy, medicinal plants and materials for shelter. Yet agriculture can also expose people to occupational hazards, and increase the spread of water-related and food-borne diseases. Agricultural intensification is a significant factor in the growth of emerging diseases, including those from livestock, which are of increasing global and regional concern. Globally, poor health and unsafe food products have tremendous implications for agriculture: unhealthy farmers are less productive and unsafe food reduces market demand, a situation that cuts productivity and income, perpetuates a downward spiral into ill-health and poverty, and further jeopardizes food security and economic development. Increasing intensification of crop and livestock production and the rapidly growing market for higher-value perishable foods for urban populations is adding urgency to the need to reduce the costs of agriculture to health.

There are also issues related to the nutritional value of diets. Improvements in crop productivity in recent decades have helped make key cereal staples more accessible and affordable to the poor. However, many cereals, roots and tubers are relatively low in essential micronutrients, such as iron, zinc and vitamin A – the leading micronutrient deficiencies identified by the World Health Organization (WHO). Most micronutrients are obtained from

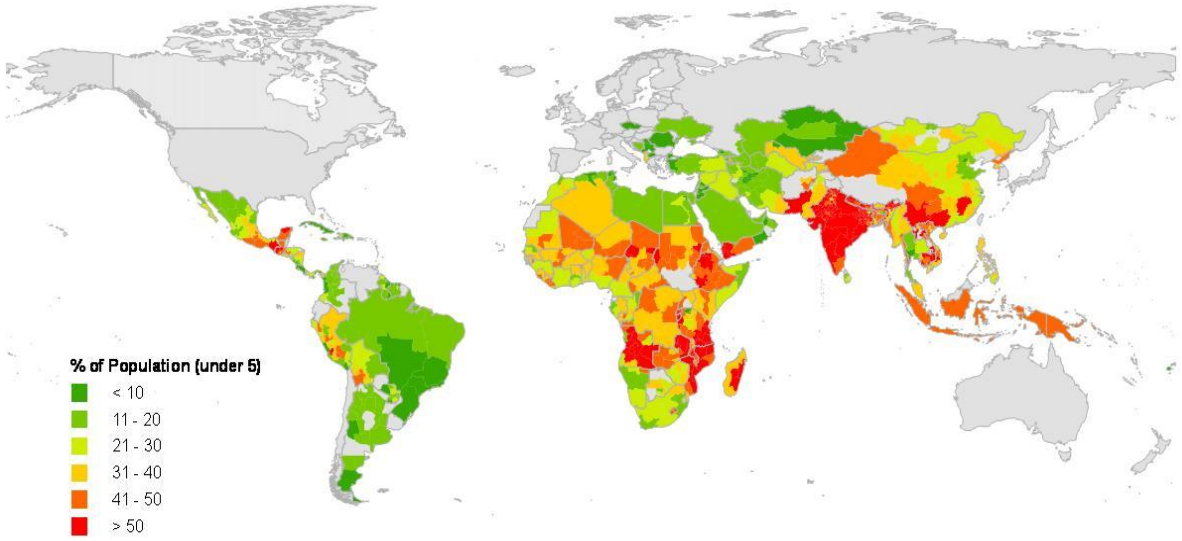
sources such as meat, fish, vegetables and fruit, which remain costly relative to cereals, making them particularly inaccessible to the poor. As a result, while approximately 1 billion people remain calorie-deficient, an estimated 2 billion are now micronutrient-deficient.

The greatest impact of micronutrient deficiency is on development during childhood. Malnutrition in pregnancy and early childhood leads to retarded development, such as stunting (Figure 3.6), with profound longer-term implications for human capital and economic productivity. Also key is the global trend toward high-energy, low-nutrient diets, which in turn is contributing to rapid growth in chronic illnesses, including cardiovascular diseases and diabetes. A comprehensive CGIAR effort to address the food and nutrition problems of the developing world must include this rapidly emerging issue in its research agenda.

These challenges and their solutions are especially relevant for women. Women are responsible for distributing nutritious foods to the most vulnerable individuals in the household. In addition, they are the principal producers of the best sources of essential micronutrients – vegetables, fruit, meat and fish – and are responsible for much of their post-harvest processing and marketing, where quality and safety issues are critical.

Sectors such as livestock, fish, fruit and vegetables offer particularly promising opportunities for combating malnutrition in at-risk groups such as women and children. Livestock and fish products, in particular, offer sources of micronutrients that are more easily absorbed by the body than are plant-derived micronutrients. Moderate increases in their consumption by undernourished populations can provide critical nutrient benefits without incurring significant risk of the chronic diseases associated with overconsumption.

Figure 3.6. Child malnutrition: Prevalence of stunting



Source: FAO 2004.
Note: Stunting is defined as height-for-age below minus two standard deviations from the international growth reference standard (National Center for Health Statistics/World Health Organization). This indicator reflects the long-term cumulative effects of inadequate food intake and poor health conditions as a result of lack of hygiene and recurrent illness in poor and unhealthy environments. The prevalence of chronic undernutrition is a relevant and valid measure of endemic poverty and is a better indicator than estimates of per capita income.

Because these agriculture–nutrition–health challenges are complex and interdisciplinary, they require an integrated, multidisciplinary analysis and response. Yet the agriculture and health sectors are seldom coordinated in their strategic planning and action.

Research under Thematic Area 4 will fill this gap. It will build on and expand the CGIAR's foundation in innovative research on this issue, including research on biofortification, crop and animal improvement, animal health and food safety, and the diversification of production systems to ensure more diverse diets. And it will showcase the benefits of overcoming the sectoral divides that have prevented agriculture, health and nutrition from working well together in the past. These benefits are expected to include the fostering of greater gender equity, in addition to higher agricultural productivity, improved food security, and better health and nutrition.

By improving poor people's access to nutritious, diverse and safe food, research under this Thematic Area will help reduce poverty and hunger (MDG1), improve maternal and child health (MDGs 4 and 5), reduce infectious diseases (MDG6) and achieve greater gender equity (MDG3).

Research under this Thematic Area will promote, coordinate and undertake cutting-edge research into the interactions between agriculture, nutrition and health, with the aim of catalyzing better nutritional and health outcomes, reducing poverty and gender inequality and improving the food, health and nutrition security and dietary diversification of poor populations, through enhanced policy and program effectiveness. It will include research in five areas:

1. Nutrition sensitive agriculture – to improve availability, access to, processing and consumption of nutrient rich and diverse foods for the poor, especially women and young children;
2. Biofortification – to increase access to nutrient rich staple foods;
3. New approaches to the control of neglected and zoonotic diseases;
4. Assessing and mitigating health risks in intensifying agri-food systems through improved food safety, water quality, agricultural practices and better control of infectious (zoonotic and emerging) diseases; and
5. Improving agricultural development planning and policy making to achieve better health and nutrition, sustainable intensification of agrifood systems, and support to marginal and vulnerable people.

The impacts of research under this Thematic Area will be measured in terms of better nutritional and health outcomes (particularly maternal and child health) in key at-risk populations, accompanied by reduced gender and other disparities in access to nutritious and safe food and clean water. This research will reduce the global burden of child malnutrition, with larger impacts in regions with the highest burden (sub-Saharan Africa and South Asia); it will achieve measurable reductions in diseases related to unsafe food and water supplies; and it will achieve demonstrated improvements in the production and productivity of nutritious crops, fruits, vegetables, fish, meat, milk and eggs.

Globally, the expected impact of work under this Thematic Area will be stronger, more efficient, effective and sustainable agricultural systems, especially in intensifying agri-food

systems, leading to healthier and better nourished farmers and consumers. This research will have particular importance for the poorest of the poor, whose diet is presently largely restricted to starchy staples.

Specific areas of innovative research may include the improvement of vegetable and fruit production, the post-harvest management of food quality and safety, and better integration of health and agricultural policy. New techniques and technologies will include: the application of genomics; spatial studies; –one-health" approaches across the socio-economic, human and animal health, medical, and veterinary disciplines; the development of information and knowledge management systems that link national, regional, and global efforts in these fields; and new genomics platforms to improve disease surveillance related to agricultural system intensification and change.

Research under this Thematic Area will link with that of several other Thematic Areas. Genetics research (Thematic Area 3) will underpin both biofortification and crop diversification; research on ICTs and markets (Thematic Area 2) will contribute to the improved marketing of perishable foods rich in micronutrients; and improved water use (Thematic Area 5) will reduce disease risk. With its focus on combining solutions in poverty hot-spots, research under Thematic Area 1 will make particular use of outputs rich in micronutrients to build both food and nutrition security.

Activities under Thematic Area 4 will require the establishment of a new and unprecedented link between international agricultural and health-related research to ensure that research investments in these two sectors are not just complementary but realize powerful synergies. This is no small challenge. But the CGIAR, with the World Health Organization (WHO) and other partners, now operates a promising Agriculture and Health Research Platform, which will be developed further to create partnerships between agriculture- and health-focused programs at the national and international levels. Partnerships will also be needed with institutions specializing in non-CGIAR crops, such as the World Vegetable Center (AVRDC) for vegetables, and in post-harvest processing and marketing. Other partners such as OIE in the animal health sector will also be critical. Private sector partnerships will be particularly important for the scaling up of solutions in post-harvest processing and marketing, as well as in realizing the benefits of research on biofortification.

It is proposed that this Thematic Area will form a single MP for management purposes, focusing on:

• Agriculture, nutrition and health.

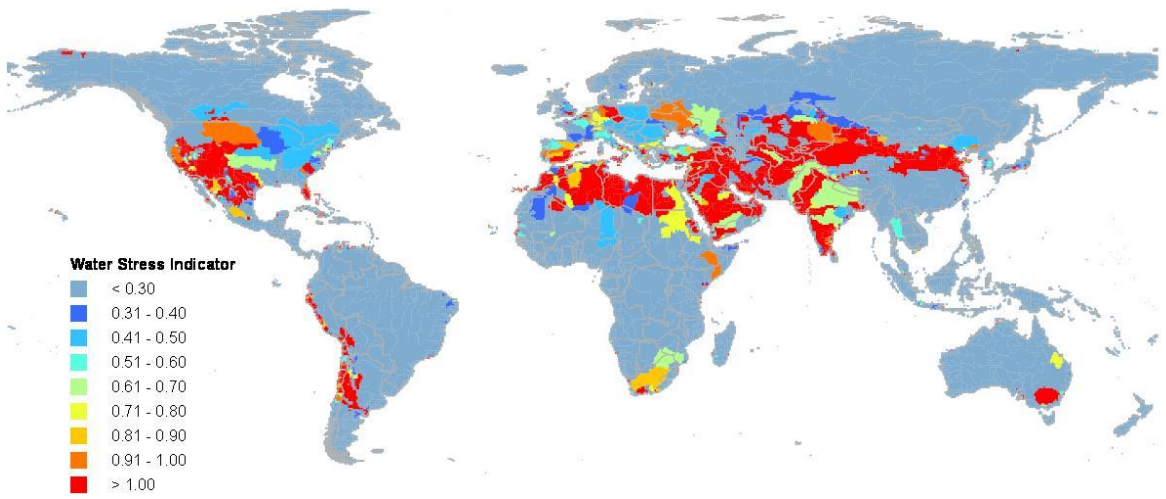
Thematic Area 5: Durable Solutions to Water Scarcity and Land and Ecosystem Degradation

One of the greatest challenges for agriculture between now and 2025 is to increase food production while using a declining share of already scarce water resources, at the same time as building soil health and reversing environmental degradation.

Over 1.5 billion people live in *physically water-scarce* areas, where water is already over-allocated across agriculture, environment, urban and industrial uses. Many of these are current or former _bread-basket' areas such as the plains of North China, the Indo-Gangetic plains of

India and Pakistan, and most of the countries of North Africa, and West and Central Asia. The consequences of scarcity in some of these regions spill far beyond agriculture, with the prospect of conflicts over water threatening social stability and economic development. The challenge in these areas is to produce more with limited water supplies while maintaining ecosystem resilience. Another 1.2 billion people have to cope with *economic water scarcity*, where water is present in nature but too costly to access owing to lack of the labor or capital needed to invest in developing supplies (see Figure 3.7). This is particularly the case in poverty-stricken areas of sub-Saharan Africa, South and Southeast Asia, and parts of Latin America. The challenge here is to find sustainable ways of improving water access and productivity to improve the livelihoods of hundreds of millions of rural poor.

Figure 3.7. Water scarcity



Source: IWMI 2004.
Note: This IWMI data set shows what proportion of the utilizable water in world river basins is currently withdrawn for direct human uses and where these uses are in conflict with environmental water requirements, defined as the estimated volume of water required for the maintenance of freshwater-dependent ecosystems at the global scale. This total environmental water requirement consists of ecologically relevant low-flow and high-flow components and depends upon the objective of environmental water management. Both components are related to river flow variability and estimated by conceptual rules from discharge time-series simulated by the global hydrology model.

Agriculture uses the major share of water in most developing countries, currently accounting annually for 3100 billion m^3 or 71 percent of water withdrawals, a share that will come under significant threat from other users over the coming decades. Within agriculture, livestock is already a major consumer, with about 31 percent of this total, and growth of the livestock sector is expected to place rising pressure on supplies due to expansion of the area devoted to feeds. Areas where the demand for agricultural water is and will be highest are also where many of the world‘s poorest farmers live. The aggregate gap between water demand and supply is projected to rise to 50 percent, 25 percent, 27 percent and 14 percent respectively for India, China, South Africa,and Saõ Paolo State in Brazil by 2030. Climate change impacts will further exacerbate water scarcity in many regions. With rivers such as the Indus, Yellow, Amu and Syr Daria already fully allocated, and with groundwater levels declining in

breadbasket regions, water availability and access will be key constraints to food production (Table 3.4).

Table 3.4. Water, agriculture and poverty in water-scarce areas

Indicator	Unit	Ethiopia	Burkina Faso	Ganges plains (India)	Pakistan	Yellow River basin	Uzbekistan	Egypt
Water availability per capita	m^3	1,506	871	1,951	1,400	256	1,868	773
Water storage per capita	m^3	48	324	*207	137	370	704	2,278
Available water	%	5	6	*34	75	92	115	120
Agricultural/total withdrawal	%	93	86	*86.3	96	83	93	86
Percent of population in poverty	%	39	46	31	24	21	33	20
Projected population by 2050	million	278	47	868	276	136	35	138

Sources: Data from AQUASTAT, FAO; CIA Factbook, Agricultural Statistics at a Glance (India); Yellow River Conservancy Commission.
Note: * All India figure.

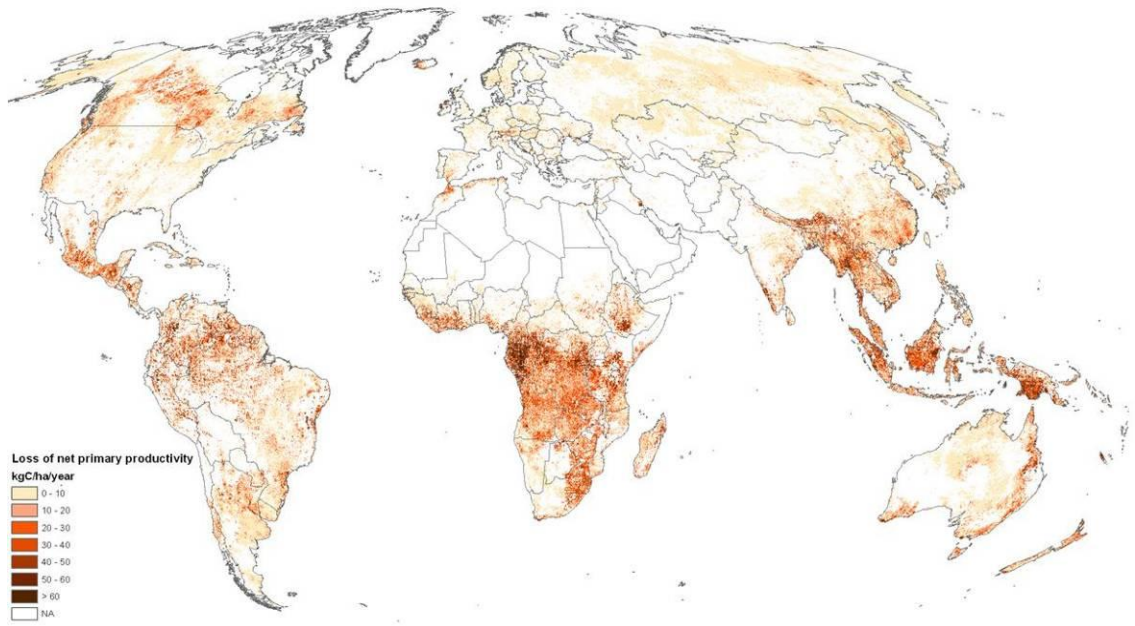
Given these limits on water, it is essential to generate more food per unit of water used in agriculture in areas of physical water scarcity. Recent studies have shown that the potential for increasing water productivity in the agricultural sector is huge and that much of this potential can be met through the wider application of low-cost technologies and management practices suitable for small-scale farmers. Net aggregate agricultural incomes could rise by US$83 billion per year as a result, according to one estimate. Increasing the water productivity of livestock and feed production systems is more problematic than achieving greater water use efficiency in crop production and will therefore deserve special attention.

Improved land, soil, biodiversity and water management is central to the three CGIAR strategic objectives. Research under Thematic Area 5 will address the United Nations conventions on desertification/land degradation, biodiversity and climate change, and the Ramsar Convention on Wetlands, as well as the food security, environmental and development priorities of many inter-governmental organizations, international donors and development banks, and the business community. We believe that, through productivity gains in irrigated and rainfed systems and judicious implicit water trade via agricultural commodities, growth in water withdrawals for irrigation can be limited to 10 percent growth over present rates globally by 2025, with decreases in withdrawals from basins where water is physically scarce offset by reasonable increases in basins where the scarcity is economic.

In many parts of the world with high levels of poverty, water access and productivity are the key constraints, rather than water availability. Across sub-Saharan Africa, current levels of water storage per person (often less than 100 cubic meters per capita) are extremely low compared with those in Asia and the developed world (1,000–5,000 cubic meters per capita). Attention must be given to upgrading water management in rainfed systems and to developing new irrigation infrastructure in order to ensure livelihoods and protect food security in the face of climate change, while maintaining ecosystem functions. Research to target investments in water infrastructure is essential, as also is the development of human and institutional capacity to overcome economic water scarcity. Women and children often bear responsibility for hauling water and stand to benefit greatly from improved water infrastructure and management.

Water shortages are increasingly compounded by soil fertility exhaustion, erosion and salinization. In many developing countries, current policies and practices have already led to severe loss of soil resources, inhibiting growth in crop yields and water productivity (Figure 3.8). The physical loss of topsoil by erosion is often closely associated with deteriorating soil structure as nutrient levels decline owing to continuous cropping without the application of fertilizer or organic additives. Elsewhere, poor irrigation practices have led to the buildup of toxic salts and elements such as sodium and magnesium that significantly reduce crop yields and cropping options.

Figure 3.8. Land degradation: Global loss of annual net primary productivity, 1981–2003



Source: Bai et al. 2007 (LADA, FAO/ISRIC).
Note: This figure shows observed loss of terrestrial carbon, captured as loss of ‗greenness' after allowing for the effects of year-to-year climate variability. Loss of greenness might occur as a consequence of soil degradation, deforestation and overgrazing.

The catalogue of land, soil and water problems, and their mutually reinforcing nature, constitute a daunting challenge given that food and animal feed production in developing countries will need to double by 2050. This is, however, a challenge that the CGIAR and its partners must meet if poverty and hunger are to be reduced, livelihoods enhanced, and human and environmental health improved.

Research under this Thematic Area will address the complex interactions between biodiversity, soil, water, ecosystems and productivity; the implications of these interactions for livelihoods; and the role of policies and institutions, as well as farm-level practices, in bringing about improvements. Payments for the maintenance of ecosystem services will be an important component. So too will be research to understand the functions of biodiversity in creating resilience and assuring ecosystem services. Work will take place predominantly in

sub-Saharan Africa, South Asia, and the West Asia–North Africa regions, with the potential for ecosystem services work in Latin America as well. It is in the West Asia–North Africa region that the risk of accelerated land degradation and desertification is currently thought to be greatest.

The overall objective of Thematic Area 5 is to sustainably improve livelihoods, reduce poverty and ensure food security using research-based solutions to water scarcity, land degradation and ecosystem services. It aims to move research into impact by:

- Delivering greater water and land productivity in rainfed and irrigated systems to enable crops, fisheries/aquaculture, livestock and agroforestry to cope with water scarcity and degradation.
- Enhancing and safeguarding land and water access for the poor so that they sustainably benefit from resource utilization.
- Improving land and soil health and water quality to reverse widespread degradation of agricultural production systems.
- Enhancing ecosystem services and building resilience through more judicious use of biodiversity to ensure sustained provision of beneficial services to poor communities in aquatic and terrestrial environments.

To achieve these objectives, the Thematic Area will support the development of options for policies, investments and appropriate governance arrangements; contribute significantly to capacity building; place an emphasis on the role of women and youth; and include a monitoring, evaluation and learning framework to adapt and improve as we move forward. To deliver research for development the Thematic Area uses a series of best bets – geographically explicit problem sets where there is high potential for impact.

Results expected from this Thematic Area include benefits for the livelihoods of up to 1 billion people in water scarce and food insecure regions. The aim is to increase crop and water productivity by 20–50 percent over the next 30 years (depending on initial levels in a region) and to reduce agricultural water demand by 10 percent in major water scarce systems.

Thematic Area 5 complements Thematic Areas 1 and 3, where water is an input into production systems, and Thematic Area 7, which addresses climate change. For this Thematic Area, the CGIAR‘s strong, boundary-spanning role goes well beyond the partners engaged in agriculture to include partners in the broader water, climate change, energy, trade and environment sectors, leading to unparalleled opportunities for addressing poverty and natural resource problems by integrating knowledge and developing holistic solutions. Because the research is aimed largely at strategic policy, practice and investment decisions regarding water, land and related ecosystems, Thematic Area 5 must engage with a broad and diverse range of partners, including policy bodies, farming organizations, national research institutes, civil society, NGOs and investors, who may be government departments, local communities, donors or the business community.

For management purposes, it is proposed that research under Thematic Area 5 will form a single MP focusing on:

• Durable Solutions for Water Scarcity and Land and Ecosystem Degradation.

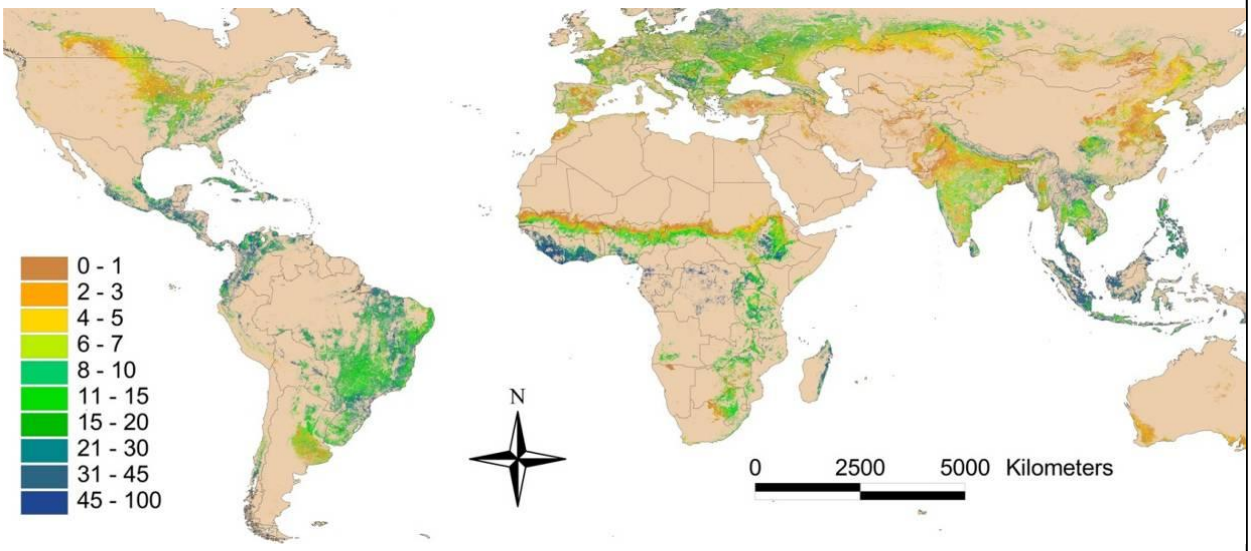
Thematic Area 6: Forests and Trees

Approximately 30 percent of the world‘s land area is covered by forests, which contain about 80 percent of Earth‘s terrestrial biodiversity. Forests are an important source of income for 1 billion poor people, of whom at least 350 million depend almost entirely on forests for subsistence and survival.

Forests support much of the world‘s biodiversity and are a major source of new crops and genes. They also provide a range of ecosystem services (such as erosion control and regulation of water quantity and quality) that are fundamental to the planet‘s wellbeing, including its capacity to mitigate or adapt to climate change. Trees store carbon and have a huge role to play in reducing emissions of the main greenhouse gases. Deforestation, mostly in tropical areas, accounts for 17 percent of current global carbon emissions and 80 percent of emissions from developing countries.

Outside the forests, some 50 percent of the world‘s agricultural land has at least 10 percent tree cover, providing vital goods and services for small-scale farmers and local communities (Figure 3.9). Some agroforestry systems assume regional or even global significance by virtue of their ability to mimic lost forest ecosystems, representing an attractive tradeoff between biodiversity conservation and carbon storage, on the one hand, and income-earning potential for their managers, on the other.

Fig 3.9: Percentage of tree canopy cover on agricultural land - 2001



Forest and agroforest products offer a highly diverse array of income-earning opportunities for gatherers, hunters, traders, producers and processors. However, some harvesting and trade activities threaten the extinction of the species involved. About 40 percent of the world‘s population relies on fuelwood or charcoal as their primary source of energy for cooking and heating. Fuelwood consumption is the second biggest cause of deforestation in the tropics after agriculture and before logging. Women are heavily involved in the management of fuelwood and carry a major burden in traditional household energy production. The production of biomass is likely to be a rapidly growing industry in the years to come, offering major new markets for developing countries‘ agricultural and forest resources. With appropriate governance and institutions to connect the poor to these markets, biomass energy production could represent a significant new opportunity for poverty reduction. But if it is managed poorly, it will exacerbate competition for land, threatening both food security and the ecosystem services provided by natural forests.

Research under this Thematic Area will address the growing risks (including loss of rural livelihoods) from imbalanced land-use change, deforestation, loss of tree diversity and the resulting degraded ecosystem services by working to improve the governance and management of forest and agroforest resources for conservation and use. This work will be geared towards promoting more resilient forest and agroforest systems, improving the livelihoods of poor people who depend on these systems, and increasing biodiversity and carbon sequestration through avoided deforestation in the tropics. Work on forests will focus on the tropical humid forests and forest margins and mosaics of the Amazon Basin, the Congo Basin and Southeast Asia, as well as tropical dry forests. Agroforestry research will range more broadly, targeting smallholder and rangeland production systems wherever these have the potential to benefit by increased tree cover.

The CGIAR system is uniquely positioned to lead the research incorporated in the Forest and Trees Thematic Area. No other network can combine its multidisciplinary expertise on the challenge of optimizing tree and forest use for rural income and environmental sustainability,

with a global comparative perspective. We can integrate understanding of forests, forest margins, forest–agriculture mosaics and trees on farms across landscapes throughout the tropics and subtropics. The various CGIAR centers involved (mainly CIFOR, ICRAF, BIOVERSITY, but also others) bring to the task a rich diversity of strengths in socioeconomics, policy and institutional innovation, and the biophysical sciences.

This Thematic Area's niche will be „upstream", in that it will work with implementing agencies to inform the design of research and the dissemination of its results. New topics will include scenario analysis of global trade and investment trends to identify forest areas most at risk of conversion or degradation; comparative analysis of the experiences of community participation in the first generation of activities under the new UN instrument, Reducing Emissions from Deforestation and Forest Degradation (REDD); improved measures of carbon in forest carbon pools; and innovative techniques for marrying remotely sensed information on forest degradation to information from local communities. Work under Thematic Area 6 will also ensure that research results are timely and relevant to policy arenas and that links are formed and maintained with advocacy-oriented organizations to extend research results and/or campaign for changes in policy.

The main outputs of research under this Thematic Area will be threefold. The first is biophysical knowledge that will lead to new approaches to enhancing the productivity and profitability of forestry and agroforestry systems, the development and dissemination of improved tree germplasm, and the creation and application of tools for monitoring and conserving ecosystem services. The second is social science research that will lead to an improved understanding of the barriers to increasing rural income from forests and trees, of ways to add value to tree genetic diversity, and of the governance and market-related issues that affect the sustainability of forest and agroforest systems. The third is policy outputs, including guidance to policy-makers on „best bets" for governance, policies and institutions that will enable the equitable participation of developing countries, and especially poor people in these countries, in REDD+ projects[20] and in payment for ecosystem services.

These three envisaged outputs will drive the following three areas of activity: improving livelihoods from forests, agroforests, trees and their genetic resources; maintaining forest goods and services in multifunctional and dynamic landscapes; and realizing the potential of forests, trees and their genetic resources to mitigate and adapt to climate change.

These outputs should in turn lead to outcomes, including demonstrable improvements in environmental sustainability, biodiversity conservation, incomes derived from forests and agroforests, policy environments and the conduct of private sector companies. Thematic Area 6 aims to contribute to a 10 percent reduction in deforestation from 2015 to 2030. Other anticipated outcomes include increased tree planting, enhanced by using appropriate genetic resources, on 50,000 km^2 of agricultural and degraded land by 2030, benefiting 500 million people; more equitable sharing of the profits from timber and other forest products with local communities; certification schemes for environmentally friendly tree products adapted for use by small-scale producers; and low-intensity managed forests on 15 million hectares of community forest land in the tropics.

[20] REDD+ is a modification of the original instrument that incorporates biodiversity conservation and socio-economic objectives into the conceptual framework for project design and implementation.

Research outcomes under this Thematic Area will be highly relevant at the local, national and international levels. They will meet objectives specified under REDD+, the United Nations Framework Convention on Climate Change (UNFCCC), the conventions on biodiversity and on combating desertification, the UN Forum on Forests and the FAO Commission on Genetic Resources.

This Thematic Area will require close links with Thematic Area 7 on Climate Change and Agriculture, Thematic Area 5 on Land, Soils, Water and Ecosystems and Thematic Area 2 on Policies, Institutions and Markets to Enable Agricultural Incomes for the Poor.

Principal partners in research under Thematic Area 6 will be advanced research institutes and global science networks, national research organizations, universities, capacity-building institutes, NGOs and private firms that are targets for the adoption of improved forest and agroforest management practices.

It is considered that research under this Thematic Area will form a single proposed MP for management purposes, which will focus on:

• Forests and trees.

Thematic Area 7: Climate Change, Agriculture and Food Security

Climate change is an immediate and unprecedented threat to the food security and incomes of hundreds of millions of people who depend on small-scale agriculture for their livelihoods. It is likely to prove a major barrier to achieving the increase in food production of 70 percent by 2050 needed to feed the world‘s rapidly growing population. At the same time, agriculture and related activities contribute to climate change by increasing greenhouse gas (GHG) emissions.

Agriculture is extremely vulnerable to climate change.[21] Although there will be gains for some crops in some regions of the world, the overall impacts of climate change on agriculture are expected to be negative (Table 3.5 and Figures 3.9(a) and (b)). Higher temperatures reduce crop yields while encouraging weed and pest proliferation. Changes in rainfall patterns increase the likelihood of short-run crop failures and long-run production declines. People in the developing world who are already vulnerable and food insecure are likely to be the most seriously affected. In developing countries, climate change will cause yield declines for all the most important crops, with South Asia particularly hard hit.

It is predicted that climate change will result in additional price increases for the world‘s three most widely grown and consumed cereal crops: rice, wheat, and maize. Higher animal feed prices will lead to higher meat prices. As a result, climate change will reduce the growth in meat consumption slightly and cause a more substantial fall in cereal consumption. Unless large investments are made in research to combat these problems, calorie availability in 2050 will actually decline relative to 2000 levels in much of the developing world. By 2050, the decline will increase child malnutrition by 20 percent relative to a world with no climate change. Climate change will eliminate much of the improvement in child malnutrition levels that would otherwise occur.

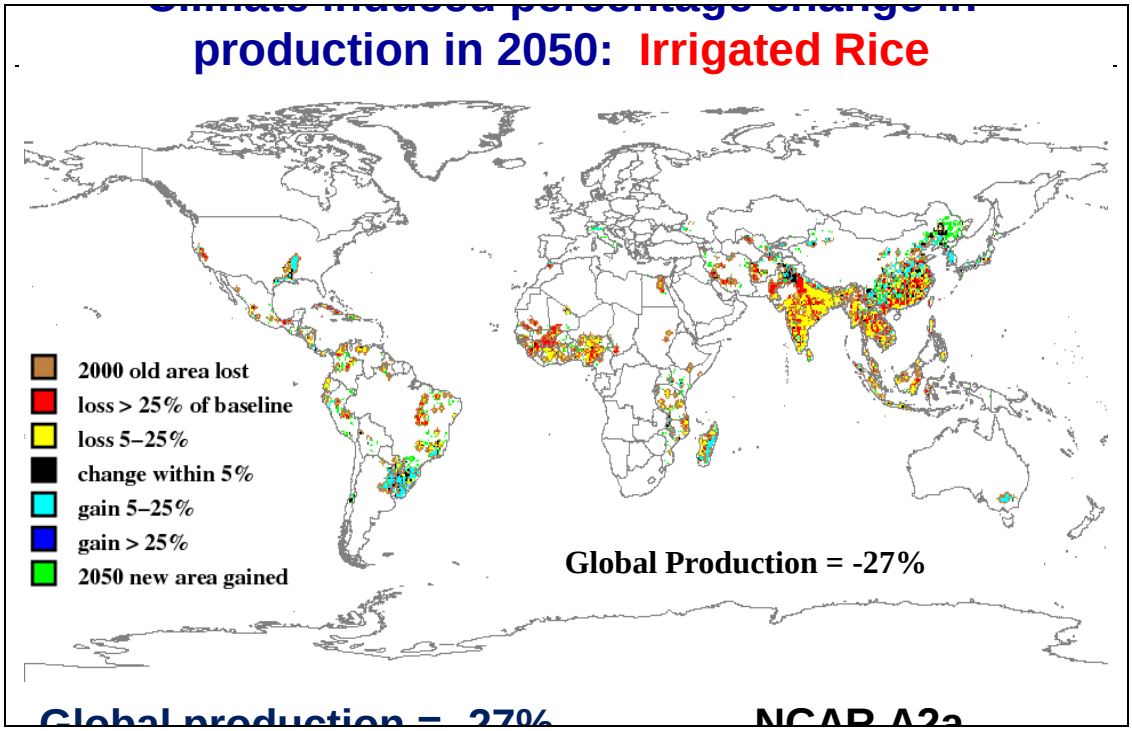
[21]. This section draws on a recent IFPRI study by Nelson et al., Climate Change Impact on Agriculture and Costs of Adaptation (2009); and on the background paper by Rosegrant et al. on the Alliance website.

Table 3.5. Yield changes in developing countries between 2000 and 2050 by crop and management system scenarios, with CO_2 fertilization (CF) and without CO_2 fertilization (No CF)—(% change)

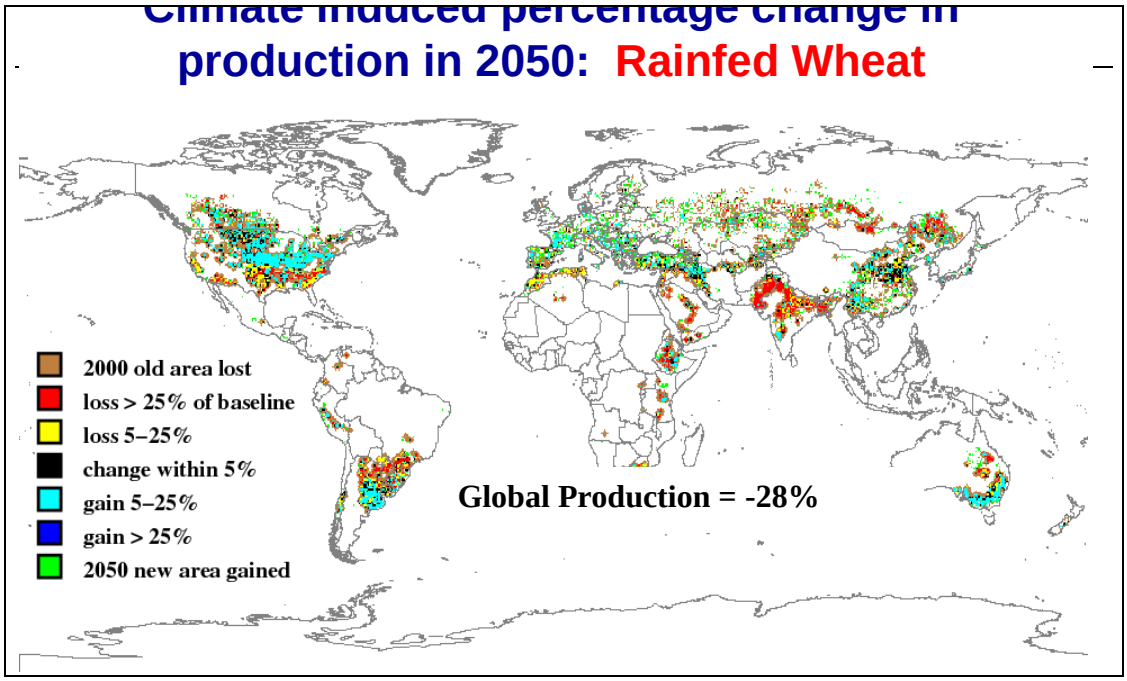
Scenario	CSIRO, No CF	NCAR, No CF	CSIRO, CF	NCAR, CF
Maize, irrigated	–2.0	–2.8	2.4	–2.1
Maize, rainfed	1.4	–2.0	6.6	–0.4
Rice, irrigated	–14.4	–18.5	2.4	–0.5
Rice, rainfed	–0.9	–0.8	6.6	6.6
Wheat, irrigated	–28.3	–34.3	–20.8	–27.2
Wheat, rainfed	–1.4	–1.1	9.4	8.6

Source: Adapted from G.C. Nelson, M. W. Rosegrant, J. Koo, R. Robertson, T. Sulser, T. Zhu, C. Ringler, S. Msangi, A. Palazzo, M. Batka, M. Magalhaes, R. Valmonte-Santos, M. Ewing, and D. Lee, *Climate Change: Impact on Agriculture and Costs of Adaptation* (Washington, DC: IFPRI, 2009).
Note: NCAR = the National Center for Atmospheric Research, U.S. model; CSIRO = the Commonwealth Scientific and Industrial Research Organization, Australia model.

Research under this Thematic Area will ensure that the CGIAR and key partners have an integrated, systemic approach to dealing with what is arguably the greatest threat to poverty alleviation and food production facing the world today. It will be global in scope,



Source: G. Nelson and M. Rosegrant, IFPRI (2009).



Source: G. Nelson and M. Rosegrant, IFPRI (2009).

with a particular focus on poor areas most affected by climate change (such as southern Africa and South Asia) and on agro-ecological systems that contribute or potentially contribute most to GHGs (such as intensive livestock systems).

While the role of forests in mitigating climate change is well understood and high on the international development agenda, the opportunities for mitigation in agricultural lands have been significantly undervalued in terms of their potential benefits in reducing CO_2, N_2O and CH_4 emissions. Forage-based livestock production is a case in point, offering mitigation via three routes: carbon sequestration, the inhibition of biological nitrification and the reduction of methane emissions associated with cattle.

The climate change impacts of livestock production have been widely highlighted, particularly those linked to deforestation in Latin America and to industrial operations in Asia. However, livestock are not always and everywhere bad for the climate, and their climate-related impact needs in any case to be considered in a broader context. In many mixed smallholder systems and in pastoral or agropastoral areas livestock are one of the few options for increasing the incomes of people who, in aggregate, have a very limited environmental footprint. GHG emissions from livestock are modest compared to the contribution made to the livelihoods of the millions of poor people who live in these systems. The complex balancing act between resource use, GHG emissions and livelihoods requires better understanding, including the development of new research methods and indicators. And the rapidly growing livestock sector urgently needs new technological approaches to reducing its emissions.

By virtue of its strong capacity for development-oriented agricultural science, its presence on the ground in major agro-ecosystems across the developing world, and its multiple networks of partners, the CGIAR is uniquely placed to play a major role in both adaptation and mitigation. The technologies developed by the system and its partners for the crop, livestock, agroforestry, forestry and fisheries sectors have the potential to play a lead role in supporting

adaptation in rural areas across the tropics. So too do the tools, methods, approaches and practices developed in such areas as soil and water management, germplasm conservation and characterization, vulnerability assessment, the identification and mapping of pests and diseases and so on. Lastly, the system's strong links with policy-makers will place it in a position of trust from which to provide advice and analysis to support decision-making and to aid in the development of more responsive institutions and policies as climates change.

Activities under Thematic Area 7 will therefore build on an existing foundation of responsive, adaptive research to develop and disseminate technologies and policies that will help reduce people's immediate vulnerability to climate variability, while at the same time conducting more innovative strategic research to pave the way for the successful management of long-term climate change. They will integrate the work already under way in the Climate Change Challenge Program and other work being conducted by the CGIAR Centers and their partners. And they will develop strong links with relevant research undertaken under other Thematic Areas (see below).

The objectives of research under Thematic Area 7 will be to provide the diagnosis and analysis required to ensure the inclusion of the agriculture, livestock, forestry and fisheries sectors in climate change policies in ways that benefit the rural poor; and to identify and develop pro-poor adaptation and mitigation practices, technologies and policies for food production systems and rural livelihoods.

Particular emphasis will be given to four areas of activity. The first is the development and implementation of diagnosis and vulnerability assessments as a basis for deciding on adaptation and mitigation strategies, from local to global levels. The second is research to develop adaptation technologies, practices, and policies for confronting near-term climate variability. The third is work on adaptation technologies, practices and policies for addressing progressive climate change; and the fourth is mitigation technologies, practices and policies for reducing GHG emissions and enhancing carbon storage.

The results expected from this Thematic Area include the development of an international lead role for the CGIAR in describing how agriculture and food production will be affected by, and in turn may affect, climate change. Research under this Thematic Area is expected to produce authoritative, comprehensive scenarios that other researchers and policy makers can use to understand how agriculture both adapts to and mitigates or exacerbates climate change. This will include a portfolio of adaptation and mitigation options and technologies, better policies at the global and national level, and a better understanding of risks and vulnerabilities.

Research under this Thematic Area will require strong links to other Thematic Areas because climate change research will be mainstreamed throughout the CGIAR portfolio. For technological adaptation, links to Thematic Area 3, on plant breeding, Thematic Area 1, on agricultural systems for the poor, and Thematic Area 5, on soils and water, will be especially critical. On institutional and policy change, links to Thematic Area 2, on pro-poor policies, institutions and markets, will be valuable. Equally important will be close links to Thematic Area 6, on forests, which will have a strong component on mitigation through avoided deforestation and increased carbon sequestration.

Strong partnerships will be developed with the broader climate change research community to ensure that the CGIAR has the latest data, tools and methods, as well as to enhance the

visibility of agriculture and agricultural research in international discussions and agreements on climate change.

This Thematic Area will form a single proposed MP for management purposes, focusing on:

• Climate change, agriculture and food security.

Capacity for addressing transversal issues

It is proposed that three centres of transversal functionality are developed to support work across the seven Thematic Areas. These are intended to provide systemwide support in the areas of gender, capacity strengthening and strategic planning.

Gender in Agriculture

It is proposed that the CGIAR invests in a system-level function for gender mainstreaming. This would work across the CGIAR to articulate critical gender issues as they apply to the CGIAR‘s mandate and to build capacity within the MPs to integrate these issues into their research, capacity-strengthening and outreach activities. No such global capacity currently exists, so it is proposed that the CGIAR will take a lead in establishing it, in partnership with other organizations that have relevant expertise and activities.

The system-level function for addressing *gender in agriculture* is currently the subject of a scoping study commissioned by the Consortium Board. The results of this study will further inform the most appropriate way for this cross-cutting system function to be implemented and to ensure the each MP will take into account the latest gender-relevant research results; best practices for sex-disaggregated data collection, analysis and reporting; related successes and failures in gender-responsive R&D are broadly shared and learned from, and the necessary partnerships are built for strengthening skills and capacities for gender-responsive technology development.

Besides supporting MPs and the development research community, and depending on the outcomes of the scoping study, this function may also undertake original gender research, including in-depth analysis of gender issues critical to the CGIAR and its partners. The aim will be to ensure that the research agenda addresses women‘s and men‘s specific priorities. It will include participatory action research and deliver rigorous research findings, exemplary practices and information exchange across MPs.

Other possible functions may include formulating short courses and organizing training events to build the capacity of all researchers and leaders within the CGIAR to design and manage gender-responsive programs and to manage workplaces where both women and men feel valued and can contribute their best. Training materials could also be developed and provided to national research organizations and universities for use in their own capacity-building programs.

Other activities may include institutional strengthening services, to support the development of an appropriate culture, with policies and norms that reflect that; incentives such as prizes and grants to encourage innovation; and information services, including a clearing-house for gender-related publications and resources.

A broad range of partners (beyond those within the CGIAR), from researchers in national research organizations, advanced research institutes, universities and think tanks, to the staff of NGOs and women farmers' organizations will be engaged in the functions of this cross-cutting initiative. Its work will also serve to inform donor strategies on gender in agriculture.

Because gender issues and appropriate responses to them will play out differently in different regions, clusters may be created to work in particular regions. The regional scope could include region-specific research and synthesis as well as deepening regional partnerships.

Results that would be expected include:

- Women exert greater influence in agricultural research, development, and policies; MPs address gender issues more effectively, enabling them to deliver on their development objectives
- Reduced gender disparities in the adoption of new technologies, resource management practices and marketing opportunities, leading to increased income and assets for women producers
- Improved nutritional status of women and children, leading to reduced inter-generational transmission of poverty
- Strengthened skills and capacities for gender-responsive and participatory technology development
- Established best practice for sex-disaggregated data collection, analysis and reporting, leading to better identification of needs, priorities and impacts of agricultural R&D
- Successes and failures in gender-responsive agricultural R&D broadly shared and learned from
- CGIAR established as a premier global organization for gender-responsive R&D.

Capacity Strengthening, Learning and Knowledge Sharing

A function to ensure capacity strengthening across CGIAR centers and partners is considered essential to realizing the benefits of the CGIAR's research. The concept of this function remains to be fully developed, since this will require partner involvement.

Partnerships begin with the design of research projects and carry on through their implementation to eventual outputs, outcomes and, it is hoped, impact. Although this effort involves many different kinds of partner, the key partnerships for the CGIAR in delivering MPs will continue to be with national agricultural research systems. These include not only public sector institutes and departments but increasingly private sector and civil society players as well. Strengthening the R&D capacity of all these partners, and particularly the weaker national partners, will be a core function of the CGIAR and a cross-cutting activity of this SRF.

Capacity strengthening in the CGIAR faces two challenges. The first is to develop and support global agricultural research networks. Several of the CGIAR's national partners operate at the cutting edge of agricultural research but still value the role of the CGIAR in networking across

countries and regions and in championing and building global capacity to generate international public goods. By building stronger networks, the CGIAR and its MPs can help stronger national systems contribute to the development of weaker ones.

The second challenge concerns the urgent need to strengthen capacity in weak national systems, through dedicated programs to help them become more effective and efficient, able to pursue research independently of support from the CGIAR or other partners. This need must be addressed in all MPs but is especially relevant to the programme within Thematic Area 1, on Agricultural Systems for the Poor and Vulnerable, which will focus on regions that tend to have weak national systems, particularly sub-Saharan Africa.

A dedicated unit to promote Capacity Strengthening, Learning and Knowledge Sharing would work at the system level to serve MPs, centers and partners in these areas. It would not serve as a substitute for the capacity-strengthening and other relevant activities that will be built into each MP, as already described, nor for those underway already at the CGIAR Centers. The Centers will continue to contribute to national capacity strengthening through:

- Formal short-term and graduate training
- Networking activities
- Support to specific countries that integrates training, technical assistance and institutional and infrastructural support; and
- Less formal activities, such as mentoring of scientists.

However, by acting as a Consortium and through its MPs, the CGIAR has the potential to integrate and focus its capacity-building activities more efficiently and to increase its portfolio of these activities. The systemwide support unit will do this by collecting, analysing and sharing the latest research findings and results on capacity strengthening. It will provide MPs with best-practice advice and tools to support capacity strengthening. It will also organize specific support to capacity strengthening that benefits from a cross-system approach, including formulating short courses and training to build the skills of all researchers and leaders within the CGIAR in strengthening agricultural research capacity.

Beyond the conventional capacity building agenda, this unit will also address the need for the MPs and their partners to harness the potential of new knowledge-sharing methods and tools, which have great potential in decentralized networks such as the CGIAR. These tools should not be seen as a substitute for conventional communications and outreach but as a complement to them.

To sum up, the activities and initiatives of the Capacity Strengthening unit will:

- Enhance the efficiency and effectiveness of the MPs
- Promote the adoption of best practices by the international R&D community
- Strengthen the capacity of national partners to innovate in agriculture
- Reach out to end users and facilitate their use of international public goods
- Increase the involvement of scientists in global research and learning networks

- Strengthen the capacity of universities to form skilled human capital for the global agricultural research system
- Promote the sharing of knowledge through new tools and methods.

This unit will be impact-oriented. It will help the MPs and their partners develop and use advanced ICTs and knowledge management and innovation systems for capacity-strengthening and other activities, so that CGIAR research outputs reach target users and beneficiaries. This effort will include providing MP partners with access to applications and resources such as databases.

Besides serving as a support unit to assist MPs, CGIAR Centers and the development research community, the Capacity Strengthening, Learning and Knowledge Sharing function will undertake original research on the ‗how to' of capacity strengthening, including in-depth analysis of successes and failures and the factors that determine these.

We suggest that the platform should have a strong focus on capacity strengthening for agricultural research in sub-Saharan Africa. Support to human capital development will be tied to strong efforts to revamp the incentive structures of national systems, so that these provide a dynamic and exciting environment in which young scientists can develop their careers.

We also suggest that the platform should be developed through a process of consultation between CGIAR and GFAR representatives and their subregional and university partners. This process should draw on capacity-building expertise in the CGIAR Centers, including the Knowledge, Capacity and Innovation Division (formerly ISNAR) of IFPRI, in FAO and in other international and national organizations. Given the growing role of the private sector in outreach and capacity strengthening along agricultural value chains, this platform should also seek to harness company contributions to the capacity-building effort.

Capacity strengthening is by nature a partnership, and the design of this cross-cutting activity must be a joint effort between the CGIAR and its research partners, represented by GFAR and its constituency. These suggestions, therefore, are intended only as an initial contribution.

Results expected from this function include:

- Enhanced participation of national scientists in global innovation systems and partnerships with other agricultural research institutions
- Strategic partnerships in the CGIAR and in the AR4D system (e.g. GFAR and others), including effective participation by national partners in MPs, leading to increased contributions to the outcomes and impact arising from research outputs
- Development and use by national systems of new ICTs and knowledge management tools for promoting innovation in agricultural R&D
- Greater engagement of universities in capacity-strengthening efforts, ensuring that MPs and their partners build an agricultural research workforce for the future
- Research and advocacy on issues that affect agricultural innovation, including standards, guidelines, tools and policies
- The delivery, use and re-use of international public goods

- Quality standards for training, monitoring and evaluation (M&E) and impact assessment as well as the promotion and facilitation of their implementation within a culture of continuous improvement
- Contributions to the scaling up of successful initiatives, methods and tool that aid capacity-strengthening, learning and knowledge sharing.

Strategic Planning and Intelligence

The future ability of the CGIAR system to make rational investment choices relies heavily on its capacity to assess how the different MPs will contribute to its strategic goals.

This third, proposed cross-cutting function in the SRF will deliver a strategic, ex-ante, R&D evaluation capacity that will enable systemwide priority setting, targeting and investment decision-making based on supporting evidence. The proposed unit will use and extend the existing knowledge bases and experiences of CGIAR Centers and will formalize these into a new, cross-center facilitation mechanism with the mandate and resources to deliver system-level analytical outputs that, by design, are highly congruent with (but do not substitute for) individual program evaluations.

The goal of this function would be to achieve urgently needed improvements in the quality, timeliness, transparency and objectivity of strategic, system-level programmatic and investment decisions, including the design and maintenance of a balanced, effective and efficient CGIAR R&D portfolio. Specific objectives include:

- To institutionalize an in-house systemwide strategy and resource planning capacity, serving the corporate planning and outreach needs of a larger, reformed CGIAR
- To apply a world-class set of tools, approaches, data and specialized knowledge to the task of continually informing the CGIAR system strategy, program and investment decisions
- To provide data and an analytical framework for the ongoing monitoring, evaluation and reporting of system-level performance indicators and outcomes for management, donor and outreach purposes
- To improve the coherence and consistency of analytical evidence supporting strategic evaluations at system, program and center levels
- To engage, deploy and strengthen *ex-ante* impact assessment capacities that already exist within the CGIAR Centers

A strategic planning and intelligence unit would be designed to address questions such as:

- Where are the major geographic hot-spots to which agricultural R&D might effectively be targeted to address hunger, poverty and environmental challenges? Where is the CGIAR currently working, and on what kinds of intervention? How do these two geographical perspectives differ? What are the implications for program design (and funding)?

- What can CGIAR investments expect to contribute to achieving internationally accepted development targets, i.e. the MDGs on hunger, poverty, health and nutrition, gender, and post-Kyoto goals (if any) on the reduction of GHG emissions?
- How many people will the CGIAR and its partners lift out of poverty and hunger? And how many will enjoy improved livelihoods, diets and health? Where? By when?
- How much land, water, soil, habitat and biodiversity can the CGIAR and its partners conserve as a consequence of R&D-mediated enhancements in productivity, policies and institutions?
- What might different programmatic thrusts contribute to increasing productivity, food security, safety and nutritional quality, as well as to income growth at the household, sectoral and national levels? Where? For whom? By when?
- What would be the most appropriate CGIAR R&D portfolio given different weights for equity, growth and environmental sustainability goals? What portfolio would maximize impact? What portfolio would minimize tradeoffs between goals?

To achieve its desired outcomes, it is expected that this function would: be undertaken by a small coordination and core evaluation team based at a Center or at the Consortium office; require a set of evaluation resources to facilitate data storage, local and virtual data access and the conduct of systemwide evaluation studies; have a strategic planning evaluation agenda setting out the milestones of key deliverables; and have a website to distribute the information outputs of the unit, including a set of evaluation databases, tools and analytical results. Most important, the unit would possess a strengthened and deepened strategic evaluation capacity that will enable the CGIAR to become a world-leader in R&D strategic planning.

4. Organization and Implementation

The Overall Conceptual Framework and its Implementation

Managing the Strategy and Results Framework

The CGIAR must deliver the outcomes articulated in the SRF in the most efficient manner.

While the Thematic Areas help group the MPs in ways that encourage alignment with the system-level results, accountability is measured at the MP level. Government and management arrangements are therefore described here in relation to the MPs. (For all but two Thematic Areas, specifically 1 and 3, the MP level is the same as the Thematic Area level in any case.)

The CGIAR Consortium Board is responsible for overall MP portfolio arrangements and is accountable for these to the CGIAR Fund Council. The Board‘s role will include ensuring that individual MPs are aligned with the SRF and that the milestones and outputs, which will be specified in a performance contract, are delivered within the agreed budget.

In the past, the CGIAR has experimented with different management regimes for Challenge Programs, Systemwide and Ecoregional Programs, and other system components. The Centers also have their own systems and processes in place for scrutinizing performance internally and externally. Although these established mechanisms provide a basis for governance and management of MPs, they must be adjusted for greater scale and complexity and to provide full accountability.

Managing the Megaprograms

The proposed governance and management arrangements for MPs will have the following components:

- Each MP will be managed by one or more lead Center(s). Specific managerial arrangements will be described in the business plans. Ultimately, the Consortium Board will decide the most appropriate arrangements for each MP, since the Board is accountable both for the efficiency of individual MPs and for the facilitation of interactions among MPs.
- MP business plans, which will indicate impacts and impact pathways, will be prepared, together with performance contracts that specify the required inputs and financial disbursements to each partner on an annual basis. To cover these and associated human resources, communication, and other MP delivery costs, MPs must be designed using full cost recovery principles.
- Each MP will have a performance contract between the Consortium and the lead Center that specifies milestones and outputs against funding on a multi-year basis for the proposed life of the MP. Rolling annual contracts will adjust future funding, contingent on the MP‘s performance against the contract.

- Lead Centers will have the option of appointing small (three- to five-person) scientific advisory panels comprising leading international experts in the MPs‘ areas of research or of using informal approaches to obtain such advice.
- All programmatic funding, whether through the fund or through restricted projects, must be fully costed. Because personnel expenses are likely to represent the largest single component of expenses for participating CGIAR Centers, the financial systems of Centers will have to include and integrate time allocation processes. The traceability of levels of effort across multiple Centers is essential when there are many sources of funding, in order to ensure the overall integrity and ―auditability" of an MP**.** The Activity-Based Costing approach adopted by the CGIAR in December 2008 provides the foundation for this accountability. These operational and accountability guidelines may require more detailed consideration from a legal perspective once the format for performance contracts is developed. Most ongoing systemwide activities will be folded into appropriate MPs.

Establishing Megaprograms with Business Plans

The Consortium Board has agreed that MP business plans will be developed, once lead Centers have been identified for the task. The business plans should meet the following criteria:

- Each MP will have its own impact pathway, linked to the SRF system-level outcomes.
- MPs‘ priorities will be guided by the system-level results outlined in this SRF. In other words they will be oriented towards productivity gains, poverty reduction, hunger reduction (including nutritional gains), and environmental sustainability; they should also integrate gender considerations and capacity strengthening.
- Each MP must describe and justify the partnerships required to establish and pursue robust impact pathways. The principle of comparative advantage will be used to identify and justify these partnerships.
- Each MP must identify and justify the geographical areas and physical research sites where it will conduct its work.
- Work within each MP must be prioritized so that investors in the MP can see which work will be funded first if sufficient funds are not available to fund an entire MP. At the same time, it is essential that expected results from each level of investment are clear and transparent.

The business plan for each MP must specify outputs, outcomes and results, as well as timelines and milestones. Important elements of the business plan are:

- Clear objectives
- Justification of the program
- Measurable results
- Centers involved and their inputs
- Management arrangements for implementation
- Timeframe

- Expected outputs, outcomes and results
- Necessary partners at the international, national and regional levels
- Support for innovation
- Integration with other MPs
- Risk factors
- Quantified impact pathway
- Monitoring and evaluation mechanisms
- Budget required.

The concept of goals that are SMART (Specific, Measurable, Achievable, Relevant and Time-bound) is particularly appropriate for MP business plans. The plans should seek to identify ambitious but achievable results during their life cycles – results that are quantified and therefore measurable. However, because research is inherently risky, it will also be important to identify risk factors, to describe how risks can be anticipated or attenuated and to outline fallback positions if outputs and outcomes do not materialize as expected. MPs should include routine mechanisms to help identify ~~"n~~on-achievement" and to stop a research approach that is unlikely to yield results (but not too early, in view of uncertainties). Some of the most important breakthroughs in agricultural research took many years, even decades, to achieve. And some are serendipitous, discovered while aiming for something else. It will therefore be important to evaluate MPs on their *actual* achievements, not solely in relation to the outputs originally envisaged.

Design and Management of Support Functions

The units that deliver on support functions will be managed through the Consortium Office, given that they will cut across all MPs and that they will provide the capacity to deal with these issues at the consortium level.

Each function will be fulfilled by a small group of experts to develop best practices and to assist the MPs in implementation. Creating such units will reduce costs by not requiring each MP to hire extensive expertise in each of these important areas. The units may themselves conduct a certain amount of research and will also facilitate learning across MPs.

Managing Core Assets and Maintaining Center Innovation Capacity

For centers to be effective in implementing the SRF and in taking on their roles in MP governance and management, it is essential that they continue to receive their own institutional funding. This funding is narrowly defined to include core functions for the programmatic work, such as critical research and network infrastructure, databases and other information resources and support, administrative and financial functions.

Collective action under the envisioned Consortium of CGIAR Centers requires joint strategy development and megaprogram design and implementation – as envisaged in this SRF. Such collective action will require centers to adopt agreed management and implementation arrangements, within which they continue their individual freedom to operate. Together with

delivering the outputs and outcomes of their MPs, they are free to pursue other agendas, provided that work is implemented on a full cost recovery basis.

The CGIAR's capacity to innovate depends crucially on creative space. Future MPs may spring from Centers' smaller pilot activities. To remain innovative, the CGIAR must continue to support individualistic and exploratory research that may not fall under the umbrella of an MP. Peer review will remain an important mechanism for assessing the quality and value of research, both within MPs and outside them.

Managing Funding for Megaprograms

Planning and implementing the MPs will challenge CGIAR scientists and managers, as well as investors, to operate in new ways. Priorities must be set in a clear and transparent manner, based on agreed criteria. Given the nature of research, commitments, both by investors and by the MPs themselves, will need to be long term. Ideally, priorities will be driven not by individual donor interests but rather by scientific analysis and best judgments on the research activities most likely to contribute to the CGIAR's vision.

Communications Strategies

Research programs can have no impact without communications. Knowledge, innovations, research results, policy assessments, practical guidance and recommendations for action are not useful unless they are communicated to those who can use them.

This role of agricultural research must be embraced by all staff involved in the MPs as well as by key external stakeholders. The support of communications professionals should also be sought, using a mix of outsourcing and core team resources as appropriate.

An "umbrella" communications strategy for the new CGIAR will make clear what the CGIAR's vision means in concrete terms and what the CGIAR will do to achieve its goals.[22] The Consortium Board will facilitate the design and take the lead in implementing a special communications effort to convey these key messages to stakeholders. The aim will be to give stakeholders confidence that not only structures but also attitudes and mindsets are supportive of the outcomes of the reform process and the new MPs. State-of-the-art communications are a prerequisite for achieving this goal; the outcome will be greater impact. The umbrella communications effort will also help the CGIAR steer the global agenda towards more pro-poor R&D, build stronger relationships with donors, partners and other stakeholders and translate research results into practical advice for achieving sustainable reductions in poverty, hunger and environmental degradation.

Each MP will need its own communications strategy. This will outline the key messages to be conveyed, the key target groups and the media and channels for communicating with these target groups. The communications strategy will be developed at the same time as the MP's business plan and should form a part of this plan. To achieve maximum synergy, the MP communications strategies will need to be coordinated with the "umbrella" communications strategy, so as to avoid the impression of competing entities.

An improved CGIAR communications strategy at these two levels will:

[22]. This section draws on a discussion paper prepared by a group of communications experts in CGIAR Centers: "CGIAR communicators" (2009).

- Link the components of the new CGIAR so that they reinforce each other‘s identities and activities
- Catalyse the coordination of CGIAR communications and engage support for communications at the highest levels of the system and its partners
- Encourage a focus on major development issues and what is being done about them through the collective effort, not on individual institutions and ~~–t~~heir” successes
- Create incentives for collective communications, rewarding communicators for multi-center initiatives focused on issues rather than institutions
- Integrate communications activities within MPs from the start, making communications a dynamic and interactive part of their work rather than an afterthought
- Tell compelling stories to showcase research impact by describing how the CGIAR‘s work makes a difference to people's daily lives
- Scale up the use of new ICTs to build capacity in communications for rural development and mainstream knowledge management in the CGIAR.

As a result of the reform process the CGIAR has an opportunity to re-position itself as a global leader in agricultural research and to greatly magnify the development impact of its collaborative work. Communications will occupy a strategic place in the Consortium Office and figure importantly in the work of the MPs. Efficiency gains will be achieved by sharing services across Centers and programs. This is not to say that CGIAR communications should be more centralized but, on the contrary, that this work can best be improved through a networking approach, aimed at achieving high-quality communications at all levels.

Investment Required

As the recent food crisis has demonstrated, more investment in agricultural research is needed urgently, at the international, regional and national levels. Funding must increase substantially if the results of research are to be scaled up sufficiently to make a sizeable impact on poverty and hunger (see Box 4).

To increase agricultural productivity by 0.5 percent annually across all regions until 2025 (a rate of increase that would lead to a food-secure world by that year) would require a massive expansion of investment in agricultural research for development above current levels – from US$ 5.1 billion per year today to US$ 16.4 billion per year by 2025. Beyond just spending more, however, two other actions need to be taken: increase the efficiency of R&D and target investments more effectively. If all three things can be done, the result will be a substantial impact at a lower total cost (although still a substantial increase over today‘s spending levels) – poverty (defined as an income of US$1.25 a day or less) can be reduced by 401 million people by 2025, at a cost of US$16.4 billion per year by that year.

This increase includes the investment needed in national as well as international public-sector research. The underinvestment in international public goods in general, and in agricultural research in particular, is known to be at least as deficient as national spending. It seems safe to assume that the share of international public goods R&D as a percentage of total public R&D spending (currently about 10 percent) will at least be held constant. If we assume, therefore, that

this share can be applied to the total required public R&D investment of US$16.4 billion set out above for 2025, it suggests we should aim for a CGIAR budget of US$1.6 billion by the same year – in other words, that the CGIAR will triple its current budget by 2025. However, donors should note that the budget will need to increase substantially well before that date, if the outcomes and impacts proposed in this SRF are to be achieved.

Box 4. Levels of investment in agricultural R&D needed to achieve specific results

To analyse the effects of scaling up and improving the efficiency of agricultural R&D, we used IFPRI's multiplier model. A business-as-usual scenario was contrasted with three R&D policy scenarios projecting R&D investment, agricultural growth, and the number of poor in each developing region to 2025 (the CGIAR reports its spending for sub-Saharan Africa, Central, East and South Asia, Latin America, and West Asia and North Africa; we then used the share of national spending to estimate CGIAR spending on each country or subregion):

- Scenario A: **productivity** increases (total factor productivity is assumed to increase annually in all regions by 0.5 percent)
- Scenario B: countries and donors become more **poverty oriented** (that is, total R&D invested in 2008 is allocated among regions in such a way as to minimize poverty)
- Scenario C: increased **productivity** is combined with **increased R&D efficiency**.

Under Scenario A, increasing agricultural productivity annually by 0.5 percent across all regions until 2025 would require over US$10 billion more in annual R&D investment above business-as-usual levels (see table)**.** Under Scenario B, more R&D investment would be allocated to sub-Saharan Africa and South Asia to minimize poverty. Most of the poor earning less than US$1.25 a day live in South Asia (698 million people) and sub-Saharan Africa (365 million people). Thus, to reduce poverty more sharply, a significant share of R&D investment should be allocated to those regions. Scenario C shows how improving the efficiency of R&D investment would lead to even better results.

Scenarios for R&D investment and impact on poverty and agricultural productivity growth, 2008–25

	R&D investment (millions of 2005 US$)		Number of poor (millions)	Change in the number of poor (millions)	Agricultural productivity growth rate (%)
Scenario	**2008**	**2025**	**2008**	**2008–25**	**2008–25**
Scenario A—0.5 percent growth in productivity	5,139	18,643	1,420	-318	0.92
Scenario B—poverty minimization	5,139	15,328	1,420	-348	0.71
Scenario C—0.5 percent growth in productivity with higher R&D efficiency	5,139	16,347	1,420	-401	1.18

Source: IFPRI multiplier model, A. Nin-Pratt and S. Fan for Strategy Team, 2009.
Note: The scenarios in this table assume a poverty line of US$1.25 a day. For details see report by A. Nin-Pratt and S. Fan (2009) on the CGIAR Alliance website. Although the assumptions made in this analysis are broadly consistent with the results and assumptions related to the scenario analyses reported under the IMPACT model, this model is not formally connected with the IMPACT model.

Returns to Investments

The MPs in each Thematic Area will be expected to deliver specific results. A preliminary synthesis of these, together with their links to system-level results, is presented in Table 4.1. Final results can only be specified after the development of business plans for each MP.

The likely results from the MPs in each Thematic Area are being assessed using various decision-support tools. Ultimately, we aim to offer a more detailed projection of the three system-level outcomes. However, because of synergies among the MPs, their individual contributions to system-level outcomes cannot be simply added up to obtain an overall picture.

Table 4.1. Expected Results of Thematic Areas by System-level Results – a Framework for Further Development of MP Specifications

CGIAR vision To reduce poverty and hunger, improve human health and nutrition, and enhance ecosystem resilience through high-quality international agricultural research, partnership, and leadership.			
System-level criteria and results			
	Lift productivity and reduce poverty: Increase in annual agricultural productivity by 0.5% to help reduce poverty by 15% by 2025, as part of an overall global agricultural R&D strategy.	**Reduce hunger and improve nutrition:** Reduction of hunger and improved nutrition in line with MDG 1 targets, cutting hunger in half by 2015 (or soon thereafter), with a focus on reduction in child undernutrition of at least 10%.	**Contribute to sustainability and resource use efficiency:** Reduction in impacts of water scarcity and climate change on agriculture through methods that increase yields with 10% less water, reduce soil erosion, and maintain ecosystems.
Thematic Areas	**Thematic Area-level results** **(indicative: will be further specified through development of MP proposals)**		
1. Integrated Agricultural Systems for the Poor and Vulnerable	Sustainable intensification of smallholder-mixed systems for productivity growth, especially in the subhumid, humid and dryland areas; and in aquatic agricultural systems, linking them to improved markets and services. Reach 250m poor by achieving broad-based productivity increases of at least 10% over 10 years Lift 60 m out of poverty	Enhanced food and nutritional security, not only in smallholder households and communities, but in urban areas that depend on rural farming and aquatic systems	Maintained or improved ecosystem health, resilience and long-term ecological integrity, as appropriate to local conditions and MP area (dryland, humid/subhumid or aquatic); sustainably managed natural resources supported by appropriate policy and institutional changes; enhanced integration from farm to landscape scales
2. Policies, institutions and markets to strengthen assets and agricultural incomes for the poor	Creation of a policy and institutional environment that allows agriculture to fully contribute to poverty reduction, sustainable rural development, and income growth Reaching 75m rural smallholders by 2030, as well as others along the value chain, by decreasing transactions costs and mitigating risks Increased access to inputs, value chains and finance for small farmers	Safety net program designed to improve the efficiency and effectiveness of coverage for the poor	Enhanced effectiveness of environmental policies

3. Sustainable production systems for ensuring food security	Easy access for farmers to eco-efficient cultivars of rice, wheat, maize, grain legumes, root, tuber and banana crops, dryland cereals and livestock (for meat, milk eggs and fish foods), as well as to sustainable and sometimes sustainably-intensified production practices and value chains; result will be productivity increases and more effective resource use New tools to improve characterization, conservation and understanding of genetic resources resulting in trait-specific germplasm for food crop productivity gains	Improved cultivars of and production practices for rice, wheat, maize, grain legumes, root, tuber and banana crops, dryland cereals and livestock and fish that will deliver improved and appropriate levels of micronutrients; greater productivity levels to reduce hunger and malnutrition levels	Eco-efficient cultivars and practices that will require fewer artificial inputs while still producing higher yields
4. Agriculture for improved nutrition and health	Increased human capital and agricultural productivity of households Improved agricultural development planning and policymaking to achieve better health and nutrition, promotion of sustainable intensification of agri-food systems, and support for marginal and vulnerable peoples in developing countries	Development of new gender-responsive approaches to control agriculture-associated diseases, including food borne infections and water-associated, zoonotic and occupational disease Nutrition-sensitive agriculture and biofortification to improve the access to, and availability, processing, and consumption of nutrient-rich and diverse foods for the poor, especially for women and young children Assessment and mitigation of the agriculture-associated health risks involved in intensifying agri-food systems Reduction in child under-nutrition by at least 10% by 2025	
5. Durable Solutions to Water Scarcity and Land and Ecosystem Degradation	Contribution to the improvement of the livelihoods of up to 500 million smallholder farmers in the next 20 years by delivering greater water and land productivity in rainfed and irrigated systems for crops, fisheries and aquaculture, livestock, and agroforestry to cope with water scarcity and degradation	Improved food security because of enhanced and safeguarded land and water access for the poor, achieved by improving land and soil health and water quality and thus delivering greater water and land productivity	Increased crop/water productivity by 20-50% over 30 years Reduced agricultural water demand by 10% in stressed systems Enhanced ecosystem services and resilience, achieved by enhancing the ability of people to manage water and land to sustain ecosystem services and maintain biodiversity within and beyond agro-ecosystems
6. Forests and Trees	Improved livelihoods from forest, agroforestry and tree-based sources of income. More equitable sharing of ~~"r~~ent" from forest products, increasing income of local communities for up to 30 m people Sustaining populations and diversity of tree species important to livelihoods including export-oriented tree-crops	Improved food security and resilience through planting of cultivated fertiliser trees, fruit and nut trees, and woody leafy vegetables. Forest-sourced foods also important buffer during food scarcity.	Maintained or enhanced forest and tree-based sources of environmental services, including biodiversity Enhanced human security through mitigation of forest and tree-based sources of emissions and carbon stock enhancement; increased local resilience through forest/tree-based adaptation measures Environmentally friendly certification schemes and low-

	Exploring potential REDD+ revenue streams for new income for reducing poverty while protecting forests.		intensity managed community forests on 15 m hectares in the tropics
7. Climate Change, Agriculture and Food Security	Enhanced crop, livestock and fisheries productivity in the context of climate change in all major systems domains in a way that brings benefits to the rural poor	Identification and development of pro-poor adaptation and mitigation practices, technologies and policies for food systems, adaptive capacity and rural livelihoods	Development of international lead role for CGIAR on agriculture/climate change Diagnosis and analysis that will ensure the inclusion of agriculture in climate change policies and the inclusion of climate issues in agricultural policies in a way that brings benefits to the rural poor

5. Transition Issues

The task of implementing this SRF for the CGIAR system must take into account the challenges of transition management, which will involve planning and launching MPs. Part of the challenge stems from the fact that the CGIAR is a complex system.

Change should take place rapidly but in an orderly manner – not in a ~~"b~~ig bang". While the assessment and discussion of the managerial implications of the SRF and the MPs is ongoing at the time of publication of this document, some preliminary thinking is offered here on the three perceived major transition issues that the CGIAR Fund, Consortium, and centers must confront, namely the existing commitments of Centers, existing systemwide activities, and the phasing in of MPs.

Protecting Existing Commitments of Centers

At present, all Centers operate with significant proportions of bilateral funding. This means that, although a significant part of the work funded through bilateral projects fits in with the overall SRF, most Center staff will be committed to delivering outputs on existing contracts over the next 2 to 3 years. External partners presumably face the same situation. Thus, the Centers will not have large numbers of staff who can immediately take part in new activities spelled out by the SRF and funded under MPs. An orderly transition of funding and research directions must be managed without the need to renege on existing contracts. In addition, the transition must ensure an orderly move from unrestricted funding to Centers to MP funding in order to avoid financial shocks that could seriously harm individual Centers.

Including Existing Systemwide Activities

A second issue relates to systemwide and ecoregional programs and challenge programs. The management models used by systemwide and ecoregional programs generally fit well within the new CGIAR and, if those programs continue, they can be integrated into the MPs.

The five challenge programs have all evolved different governance and management models. Most, if not all, of these programs are expected to contribute significantly to MPs, and a case-by-case approach to handling their contribution and integration into the MPs will be used.

To continue under an MP, however, existing programs or other work must demonstrate a clear link to the outcomes required and defined under the SRF. If this link cannot be shown clearly and explicitly, the work will have to be terminated on completion of existing contracts, unless the center concerned can fund it independently. Work that continues under an MP must be explicitly included in it and made subject to the performance contracts.

Phasing in Megaprograms

The Strategy Team proposes a phasing-in of the MPs in the following six steps:

1. Once endorsed by the Consortium Board and the Funders Forum, the SRF, the MP portfolio, and the fast-tracked MPs can move forward. The SRF will be used to frame the further design of the MPs that are not fast-tracked. The fast-tracked MPs can start being

implemented once they are approved by the Fund Council, and must maintain the clear vision that they are part of a broader portfolio.

2. The Consortium Board will confirm lead centers that will develop the MP proposals and business plans with key partners.
3. This final version of the SRF and the portfolio of MPs having been submitted to the Consortium Board at its May meeting, together with business plans for fast-tracked MPs, the next step is for the Fund Council and Funders Forum meetings to discuss the Consortium Board's recommendations at their July meetings.
4. As part of MP development, existing CGIAR activities will be assessed by the Consortium Board, in cooperation with the Centers and key partners leading the MPs, against the selected portfolio of MPs. Partnerships, both existing and new, will be factored in as well. Different options will be examined, including:
    - Research identified in the SRF and MP portfolio that is already reasonably *well established and organized* within the system can initially be mapped into MPs with a light touch
    - Research identified in the SRF and MP portfolio that already exists within the system but in a *fragmented or partial* form will require a significant effort to remap into an MP
    - Other research identified in the SRF and MP portfolio will require a new initiative to design as an MP or part of an MP, from scratch
    - Research and other activities within the system that do *not fit* the portfolio of the SRF will be phased out, unless independently funded by centers at full cost.
5. Properly planned MPs that have been approved by the Consortium and the Fund will be implemented under the SRF.
6. The fast-tracked MPs will undergo early review and monitoring in order to maintain learning and an orientation towards results. Given the diverse nature of MPs, this monitoring should not take a one-size-fits-all approach.

All MPs have areas of activity that can be fast-tracked and early business plan development will be able to identify these areas without jeopardizing the strategic portfolio and results orientation.

Strengthening the CGIAR's Strategic Capacity

Developing a new strategy at the system level has been a big challenge for the CGIAR. This is the first time that this has been done and the analytical basis had to be assembled from scratch. Now that it has been, it may come in useful for similar exercises in the future.

In a rapidly changing world of ever-greater complexity, the CGIAR needs to be able to anticipate and respond to new challenges, harnessing the best of science to address global food, agricultural and environmental problems. The new CGIAR must have the capacity to look ahead and work with partners to undertake strategic studies so that it can adjust its research portfolio and reinvigorate its SRF at regular intervals. The Consortium Board, in conjunction with the

International Science and Partnerships Council (SPC), will need to explore options for establishing and institutionalizing such a capacity.

The functionality, skills and expertise that will be developed to address the three identified cross-cutting issues outlined earlier, especially for the areas of Capacity Strengthening, Learning and Knowledge Sharing and for Strategic Planning and Intelligence, will contribute to, help build and ultimately form a part of this institutional capacity.

Conclusions

The recent global food and financial crises, together with volatile energy prices, natural resources depletion and emerging climate change issues, threaten the livelihoods of millions of poor people. They also act, and will continue to act, as a destabilizing force in many developing countries, threatening peace and security worldwide. These challenges require coordinated, multifaceted, science-based technological, economic and policy approaches.

The CGIAR has a key role to play in addressing these challenges. The system‘s new results-oriented strategy equips it to do so. Nevertheless, a results-oriented research system must be managed with due attention to the unpredictable outcomes of research and the tendency of science to be full of surprises. Freedom of research and space for ―blue-sky" innovation and experimentation are necessary if the power of research for development is to be harnessed.

There can be no doubt about the strong role of agricultural research, in concert with other development investments, in promoting poverty reduction and economic growth: investments in agricultural research typically rank first or second in terms of returns to investment reduction, along with investments in infrastructure and education. A new and broad-based consensus is emerging that investment in agriculture and in related research and innovation must be accelerated.

The SRF presented here is for the CGIAR as a whole, not a partial program. Ambitious but realistic results have been, and continue to be, defined. Investors should know what they can expect when they invest in the CGIAR.

Driven by the SRF, the CGIAR‘s work will have impacts on hundreds of millions of people. A reformed and more efficient CGIAR, working together with its partners, will not only help increase the productivity of important agricultural commodities, improve the management of the natural resources base and strengthen policies and institutions through its own research, but will also be better able to link with partners from the private sector to end users, especially farming communities. The resulting system will yield high payoffs to development investments and contribute significantly to global food security and poverty reduction.

Appendix 1: Process and Sources

The overall framework and objectives of the SRF were built over many months of research, analysis, consultation, and discussion. The overall approach taken was to:

- Consult broadly with research communities inside and outside the CGIAR and to use related systematic surveys
- Draw on modeling and mapping tools and studies; and
- Communicate with leaders in relevant professions and with well-known visionaries.

Much of the work is documented in the following materials:

- Scenario analyses using the IFPRI IMPACT model (~~–~~Agriculture and Food Security under Global Change: Prospects for 2025/2050")
- Simulations of the needed scale and impact of agricultural R&D investment (~~–~~R&D Investment in National and International Agricultural Research: Productivity and Poverty Impact and Allocation among Regions")
- Comprehensive mapping (~~–~~Geographic domain analysis")
- Decision support with an analytical hierarchy (expert choice) model (~~–~~An AHP-Expert Choice Model for the Strategic Results Framework of the CGIAR")
- Large-scale scientists' survey of key opportunities for international agricultural research (~~–~~Analysis of the Questionnaire for Elicitation of Key Opportunities for International Agricultural Research")
- Workshops with leading scientists (~~–~~Summary Report from the Technical Design and Implementation Meeting of Scientists")
- Workshop on poverty (~~–~~Current Status and Future of Poverty Research in the CGIAR"); and
- Report on gender in the CGIAR strategy, with findings from e-consultations (~~–~~Recommendations for Gender Integration in the CGIAR Strategy and Results Framework").

All of these materials are available on the CGIAR Alliance website: https://sites.google.com/a/cgxchange.org/alliance/welcome?AuthEventSource=SSO.

The initial steps in the process of working from the system-level objectives to a series of Thematic Areas and MPs that would deliver them was iterative and evolutionary, and is described in detail in documents at this web location: http://docs.google.com/viewer?a=v&pid=sites&srcid=Y2d4Y2hhbmdlLm9yZ3xhbGxpYW5jZXxneDo1YzdhMGRmYTQwZDhkYWQ4

To address specifically where the CGIAR should focus its investments, comprehensive and innovative mapping methods were used to complement the modeling used to develop the SRF and the MPs for research. This approach brought together for the first time information on poverty, production, market access, and ecosystems challenges in spatially disaggregated ways. It also helped to identify subregional and agro-ecosystem priorities and hot-spots for R&D activities. The detailed mapping of multiple, overlaid categories of information can contribute to the detailed planning of the new MPs, now under way.

A large-scale survey of scientists was also undertaken and used to explore Thematic Area and MP opportunities. About 400 scientists participated, suggesting between them more than 500 research opportunities. Each of the Thematic Areas and MPs were and will be further scrutinized in view of these bottom-up ideas. The findings were also used in the regional consultations undertaken by GFAR.

We acknowledge that the SRF is not yet perfect. Inputs obtained at and since GCARD have led to improvements, but greater precision in the results to be generated through the implementation of the MPs will require the development of the detailed business plans for the MPs. It is expected that after the MPs are up and running, the SRF can be updated with greater details on the expected results, and this can then be presented at the next GCARD meeting.